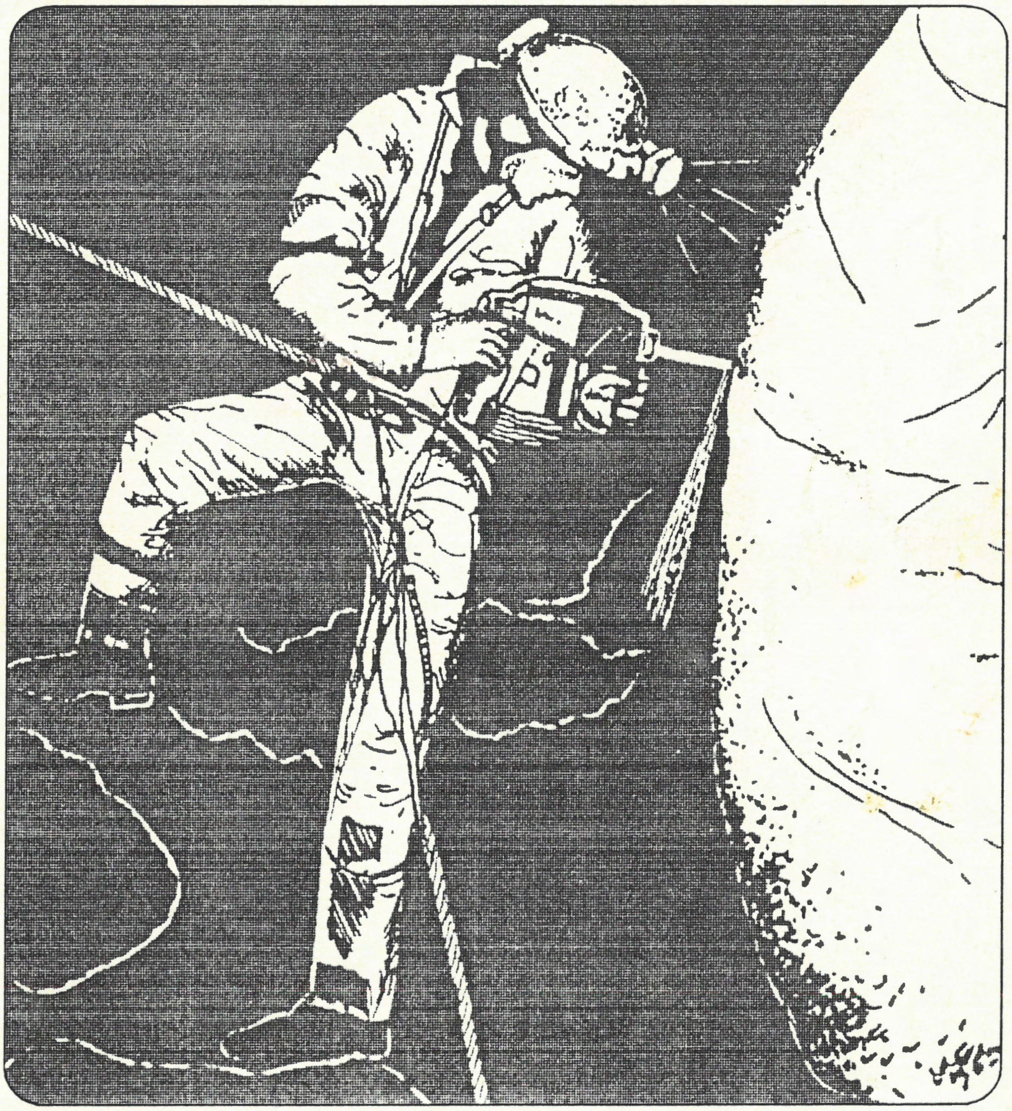
The Bulletin of the
South African Spelaeological Association

The 1993 CHIMANIMANI EXPEDITION



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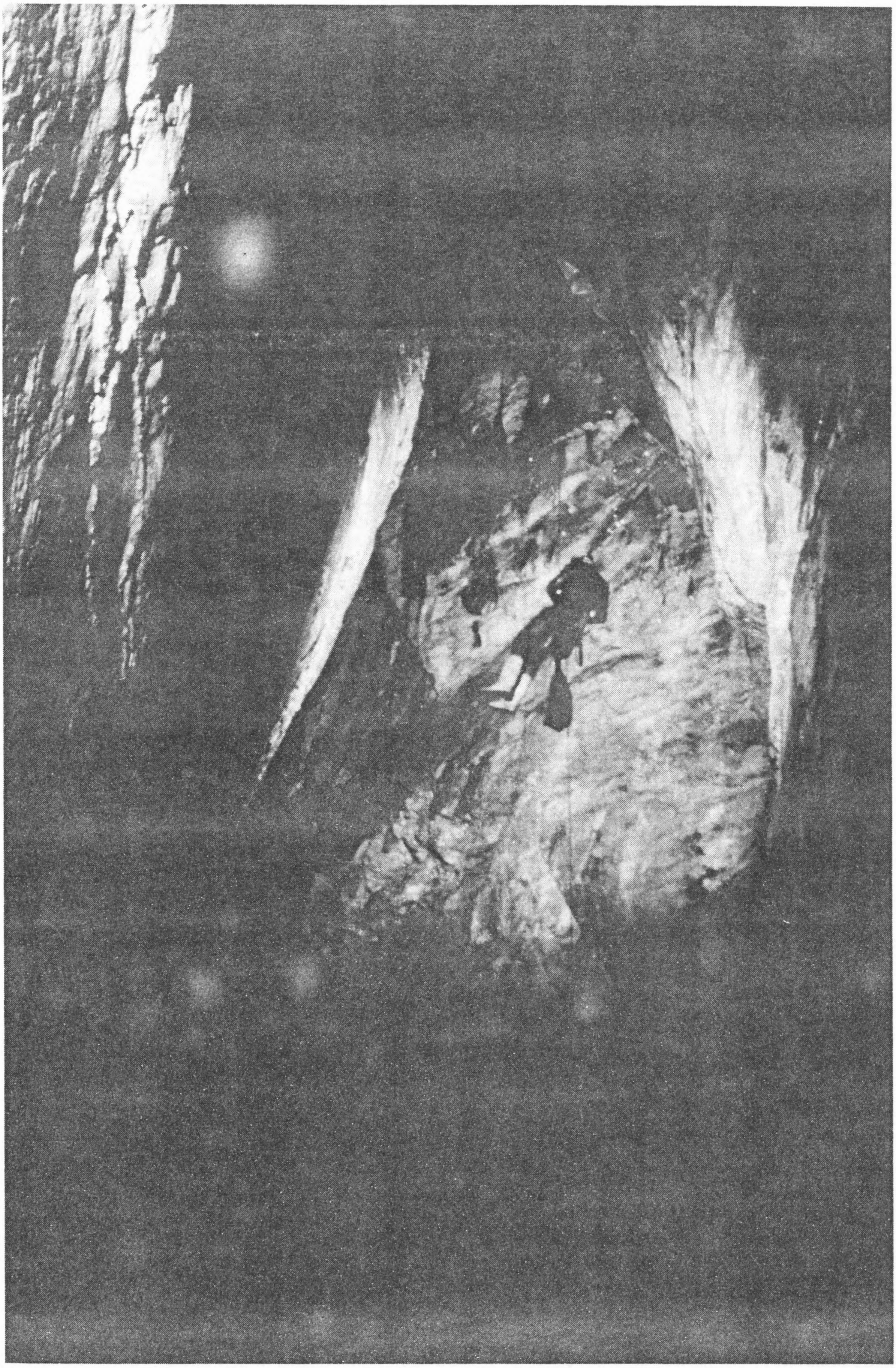

Dave Ward abseiling down the AK47 pitch in 'Hecate's Crack', Big End Chasm. (T.F. Truluck)

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The 1993 CHIMANIMANI EXPEDITION

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THE 1993 CHIMANIMANI EXPEDITION

Abstract

T.F. Truluck

The 1993 Chimanimani Caving Expedition was the first major caving expedition to the deep sandstone/quartzite shafts in the Chimanimani National Park in Zimbabwe. As a result of the findings of this expedition, the Chimanimani Mountains should be recognised as one of the most important deep sandstone/quartzite caving areas in the world, as are the Mountains of the Roraima Formation in Venezuela.

The expedition was conducted from 29 July - 1 September 1993, including two weeks travelling time, spending a total of 20 days in the field. Six new caves were discovered, surveyed and photographed, and one previously bottomed cave, Bounding Pot, was surveyed to -194 m. Four of the caves were found to be over 150 m deep and over 1 200 m of vertical cave was rigged. Mozpot, a cave at the bottom of a huge doline just within the Mozambique border, was explored and surveyed to -90 m.

Mawenge Mwena was the deepest cave surveyed, and at -305 m it is the deepest cave in southern Africa and the 7th deepest sandstone/quartzite cave in the world. Big End Chasm has the world's largest chamber in a sandstone/quartzite cave: 90 m high by 70 m long and 15 m wide. All the caves were permanently bolted with stainless-steel bolts donated by Hilti.

All the surveyed cave entrances and dolines were located in relation to one another by means of a surface survey. A cave with a resurgence about 1·5 km away and 500 m lower than the main caves was surveyed and explored, but after 150 m it became too narrow. A dye test between Bounding Pot and the Resurgence Cave was inconclusive. Fauna collected in the caves were not cave adapted, apart from two species of insectivorous bats. A very large doline and an area with large labyrinthine rifts and pavement pseudo-karst were discovered in the newly explored area just within the Mozambique border.

Introduction

A. Koliasnikoff and T.F. Truluck

The world's supply of carbonate caving areas is being rapidly explored and the number of accessible and unvisited areas left for exploration by caving expeditions is shrinking every year. Interest in pseudo-karst has increased as opportunities for exploration have become more limited. New discoveries of significant sandstone and quartzite caves are being reported yearly, the most notable examples being those found in Venezuela and southern Africa (Le Roux et al 1992; Inglese and Tognini 1993; Urbani 1993b).

Many cavers do not seriously consider the idea of caving in non-carbonate rocks. However, caves are also found in, among others, sandstone, quartzite, granite, salt, basalt (lava), conglomerate and ice. However, sandstone or quartzite caves are usually regarded as little more than overhangs which may contain rock art and archaeological sites. Even the great sandstone dolines of Venezuela are not regarded as caves because they are, for the most part, huge rifts or pits open to the sky; although this is a misconception because some have cave passages of up to a kilometre in length extending from their bases.

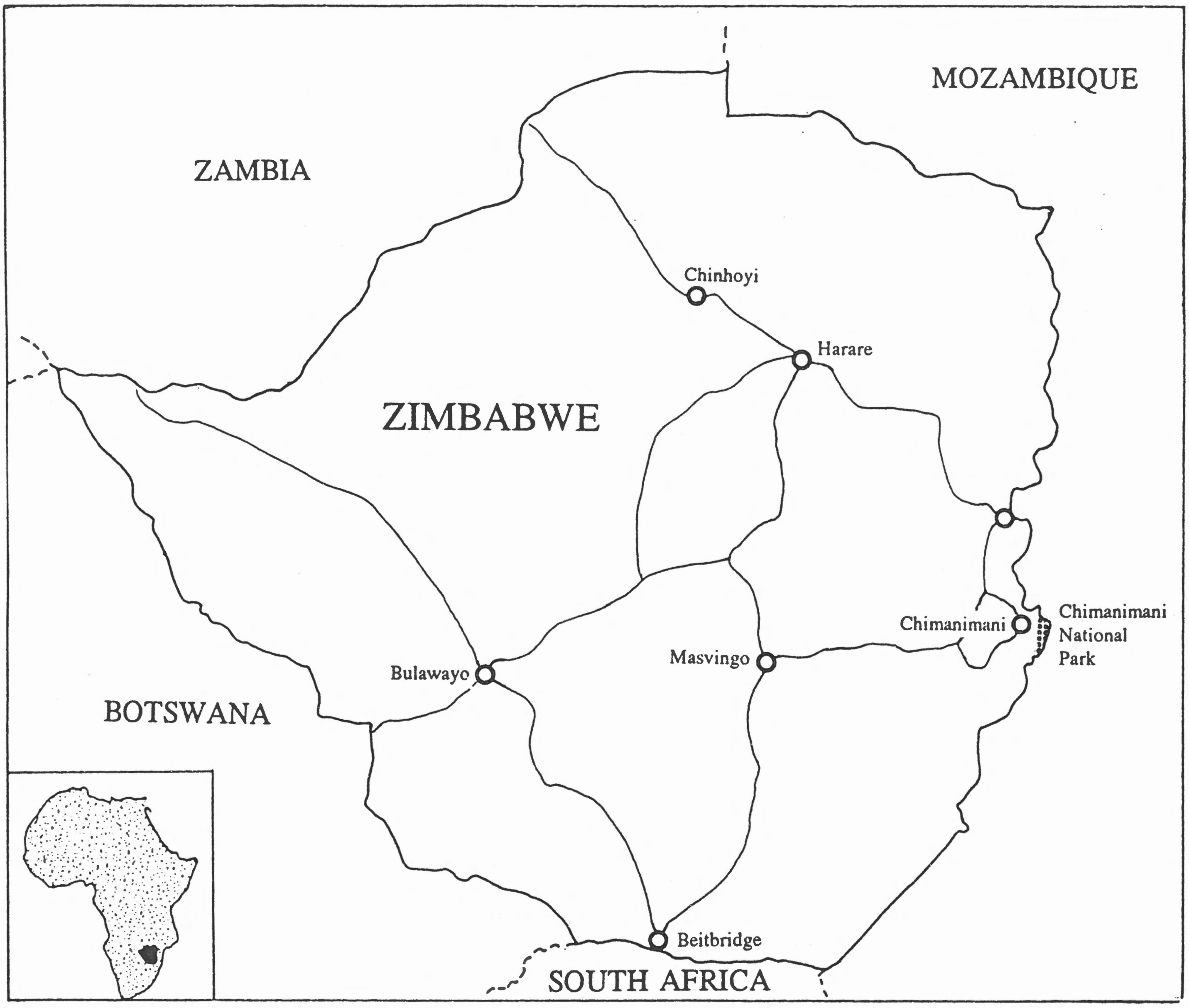
What of southern Africa? In South Africa there are two main areas where quartzite caves are found, Cape Town and the northern Transvaal. Towering 1000 m over the port city of Cape Town is Table Mountain, one of the world's best known physical landmarks. Table Mountain is home to a number of quartzite cave systems with individual surveyed lengths of up to 1·6 km and depths reaching -65 m.

The Cape Peninsula is also the home of the Cape Section of the South African Spelaeological Association, a small, but thriving caving club, founded 40 years ago, by pioneering cavers who explored these Table Mountain quartzitic sandstone systems. What better place from which to launch an expedition to the quartzite Frontier Shafts in the Chimanimani Mountains of the Eastern Highlands of Zimbabwe?

Cavers first visited the Chimanimani National Park in 1990 (Howell 1990) (see map in Figure 1). A subsequent expedition in 1992 achieved notoriety when the four team members were arrested on charges illegal mining and prospecting as well as damaging National Park property by placing bolts (Le Roux *et al* 1993; Aucamp 1992a and 1992c). The 1992 expedition was also notable for the discovery of Jungle Pot; at a then depth of -250 m it became the then deepest cave in southern Africa and the deepest quartzite cave outside Venezuela (Le Roux *et al* 1993). Information from these earlier trips suggested the huge caving potential of the area, and it was decided to launch a major expedition to the Chimanimani Mountains in 1993.

The 1993 Chimanimani Expedition was similar, in many respects, to some of the classic historic expeditions which set out to explore unknown, remote and dangerous places. Indeed, the sense of isolation that we experienced on the rugged peaks of the Chimanimani National Park must have been similar to those that the great explorers must have felt when exploring Africa several centuries ago. The months of planning and organising, the remoteness, the ruggedness, the 6 day journey to Chimanimani, the hiring of over 65 porters, the isolation, the unknown and the danger all contributed to a memorable experience for those involved.

This is the report of that expedition. We hope that this account will be of interest to cavers worldwide, and that the report will make a useful contribution to the steadily growing literature on caving in quartzite !



Map of Zimbabwe showing the major towns, major roads and the location of the Chimanimani National Park

Expedition Sponsorship

T.F. Truluck

Any international expedition inevitably costs more than initially expected, and requires specific dedicated equipment that is perhaps not likely to return from the expedition intact. It was therefore decided from the outset that we would be seeking sponsorship for food, equipment, and cash. In January 1993 we received our requested caving permit from the Zimbabwean authorities, and expedition planning could commence in earnest. A sponsorship drive was launched shortly afterwards, in March 1993. None of the expedition members had any real experience in fund-raising or sponsorship drives, none held influential positions with large businesses and, in fact, several of the members were unemployed. We had to learn, and learn fast.

The first step was to obtain some information on how to go about obtaining sponsorship. An article by Stone (1988) was useful, but the most valuable reference was the excellent *Caving Expeditions* published by the Expedition Advisory Centre of the Royal Geographical Society and the BCRA. This publication contains a wealth of useful information on all aspects of organising a caving expedition. Weekly meetings were then organised to involve the members of the expedition in the sponsorship drive. Equipment and food were listed and members were given specific tasks to do - locating potential sponsors, obtaining the names and telephone numbers of marketing/sales managers, writing letters and other administrative tasks. The meetings were also useful in updating the members and keeping up morale and momentum. Some members had more time and flair for obtaining sponsorship, but they did not feel too pressurised if the others were also pulling their weight, no matter how little. Everybody was assigned tasks and was expected to complete them.

There were three key items of sponsorship which were crucial to the success of the expedition. (1) A portable hammer drill. (2) A portable petrol driven generator. (3) Caving rope. Without these three items, the expedition could not proceed. The sponsorship drive got off to a spectacular start when Hilti in Cape Town agreed to lend us 2 used TE-10A hammer drills, 6 batteries, 2 chargers, and all the fastening equipment, particularly the necessary large stainless steel resin bolts and expansion bolts. All in all, about R20 000 worth of equipment. The generator was next. Midmacor, offered us the use of a brand new Honda EM 650 portable generator. It weighed only 23 kg, but put out an impressive 750 W of power.

The rope was a bit more of a problem. Edelrid in Germany, agreed to supply us with discounted 10 mm Superstatic rope. We were quoted a good price of about R3·50 per metre. However, they would only supply it through a local supplier who quoted us a landed price of R8·50/m. Thankfully Camp and Climb came to the aid of the Expedition, and let us buy 600 m of rope at R6·00/m, as well as very generous discounts on other hiking/climbing/camping goods.

While Le Roux and Truluck had been procuring the 'big three' items, the others had been scouring the yellow pages and supermarket shelves, or contacting old friends who might be useful as contacts. A comprehensive list of possible sponsors was compiled, listing company names, products made/distributed, address, telephone and fax numbers and contact persons. Andrew Penney kindly designed the expedition logo, letterhead and compliments slip, Truluck designed information fliers and David Harley and Kenda Taylor planned a food list.

Once all the back-up work was completed it was, by and large, left to Le Roux and Truluck to contact all the companies and obtain sponsorship. Later Pete Aucamp, who was working in Johannesburg until June 1993, also assisted. It was a full-time occupation. Mr. Yusuf Kerbelker, a friend of Truluck's, generously allowed us the use of his fax machine. Without a fax, it would have been very time-consuming obtaining sponsorship.

Slowly, the sponsors started responding. There were some major disappointments but, on the whole, we were incredibly encouraged. We had a 50% success rate - 49 sponsors and 49 refusals. Our biggest success was from the industrial sector which supplied us with caving hardware. We usually received what we requested, and met with incredible interest from the managers who supplied us with their products. We initially did not think that procuring food would be a problem. We had quite a few refusals, but slowly the food started arriving. Again enthusiasm from the suppliers was encouraging. Many went out of their way to help us, both in procuring the sponsorship and then delivering the products. We also tried to obtain money from various sources, but we were spectacularly unsuccessful. The only cash donor was Mrs. Enid Brigg who donated R200. Other cash donations were from members who abandoned the expedition and forfeited part of (and in some cases donated all) their deposits and initial payments.

Kenda Taylor in Big End Chasm making the best of some our sponsor's products.

The sponsorship drive was hard work, but the enthusiasm of the response was very heartening. The 1993 Chimanimani Expedition would therefore like to thank the following people and organizations for their generosity, support and assistance. Without them, this expedition would not have been possible.

- The Zimbabwe National Parks Board, including the staff of the Chimanimani National Park.

- The staff at the Chimanimani Police Station and Central Investigations Department.

- The Zimbabwe Mountain Club.

- Ms Sanchia Long, Mr Richard Mitchell and Mr Bill Mitchell. In addition to being team members, they managed to transport us and our gear to Chimanimani and back to Cape Town without any serious problems. They also provided much needed moral support before, during and after the Expedition.

Our commercial sponsors, major sponsors shown in bold type:

Alcom (Lent Radios)
Aquarius, Lycra suits
Backpacker (Discount)
Becketts, Beverages & discount
Bokomo (Breakfast cereal)
Borden (Klim milk powder)
Mrs Enid Brigg (R200)
Bromor Foods (Beverages)
Camcor (Slide-mounts)
Camp and Climb (Discount)
Creative Colour (Film processing)
Diva Products (Dehydrated food)
Duracell (Alkaline batteries)
Filmair (Aluminium angles)
1st National Battery (Mining Lamps)
Gripper (Survey tapes)
Haggie Rand (Hardware)
Harmony Products (10kg pasta)
Hilti (Drills etc)
Huletts (40kg sugar)
ISM (Loan of PS2 notebook)
Inani Products (Inani TVP)
Integral Safety (Oversuits, bags, discount)
Interpex (Foil packed and tinned food)
Jabula (Dehydrated food)
Yusuf Kerbelker (Fax facilities)
Kurt Rietman (Discount on salami)
Langeberg Co-op (Jam)
Maxims Packers (Shogun noodles & tuna)
Melrose (2340 cheese squares)
Midmacor (Honda Generator)
Mitchell's Brewery (Beer)
Multipak (Duct tape)
Ozalid (Water-proof paper)
Pako (Pickles)
Peninsula Beverages (3 cases Coke)
Pick 'n Pay (R500 vouchers)
Polyoak (Water containers)
Rawlbolt (Duplex Rawl Bolts)
Royal Beech-Nut (Mars bars)
2nd Skins (Lycra suits)
Superior Beef (Discount on biltong)
Tastic Rice (Rice)
Toco (Cape) (Discount hardware)
Tuna Marine (Tinned Products)
Uniplastics (Plastic bags)
Van Leer (2 litres dye)
Vynide (Discount on PVC)
Willards (Crisps)
Wonderfoods (Dehydrated food)
Zero (Discount on wetsuits)

- Mr Neil van Zyl (Beaufort-West) - who helped us find a replacement for a lost trailer wheel.

- Mr Hein van Huyssteen (Pietersburg) - who kindly fixed a split wheel rim on the Land Rover on a Sunday morning and did not charge us.

- Mr Tony and Ms Uschi Truluck (Johannesburg) for allowing crowds of scruffy, tired and irritable cavers the use of their home as a base on both journeys.

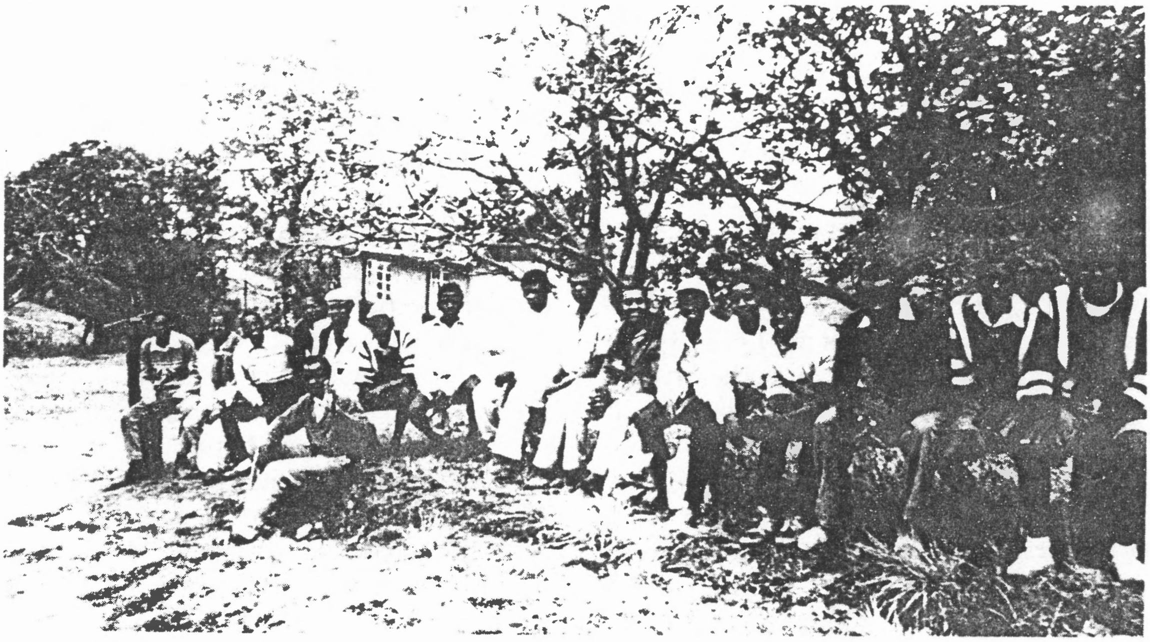
- Mr Andrew Penney for designing and printing our logo and letterhead and editing and typesetting this report.

- Ms Pene Ward, long-suffering girlfriend (now wife) of Tim Truluck, who tolerated a continual stream of caving and cavers for almost 7 months.

- The Cape and Transvaal sections of the South African Speleological Association.

- The Department of the Surveyor General Zimbabwe, Zimbabwe Geological Survey Department and Bulawayo Natural History Museum.

- The Committee and members Western Cape Branch of the Mountain Club of South Africa, and individual members of SASA for lending us rucksacks and other items of equipment.



Some of our porters at the Base Camp, Chimanimani National Park. (T.F. Truluck)

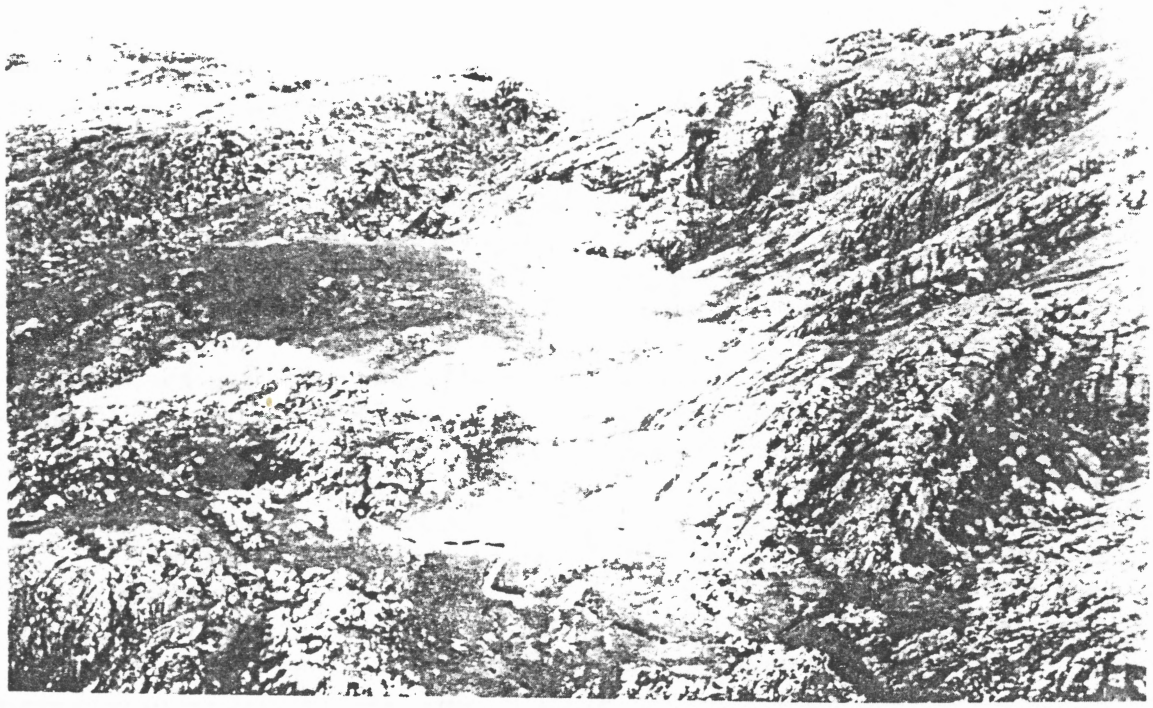
Our many willing porters:

Dubs Captain	Jeffery Mafura	Mateu Moyana	Dumisani Mashava
Shepherd MauMau	Cephas Khumbula	Zondani Chisare	Moses Maronga
Nelson Konzo	Weston Chikwaza	Philimon Gweture	Enock Mpunga
Lucky Mamvara	Obert Baranda	Edmore Mtisi	Temba Maposa
Zvidzai Tambadga	Julius Mapurazi	Lyman Beta	Phillimon Gweture
Philip Kitsimani	Eliot Annahuu	John Mhlanga	Caleb Mfote
Douglas Mtisi	Cephas Mashava	Mashebha Mfoorere	Isaac Hlobozawo
Mathew Chigariso	Reginald Mtetwa	Douglas Mpahlo	Lovemore Mparingwe
Same Makondo	Tobbias Hlobozawo	Arnold Magena	Zondani Chisare
Gondai Dhanzi	Pecy Mhangira	Takesure Sithole	Soloman Gweture
Takemore Piyoza	Soloman Mazibiye	Turai Madhobhe	Rubber Kumbula
Hazvinei Mkondo	Trymore Magume	Mateu Simango	Chigariso
Willison Chikwaza	Arnold Mafura	Bornwell Piyoza	Witness Ugaro
Zacharia Jose	Clemence Chikide	Denny Chikukwa	Fungai Mashava
Johane Mahuku	Lovemore Paunga	Denny Dzitiro	

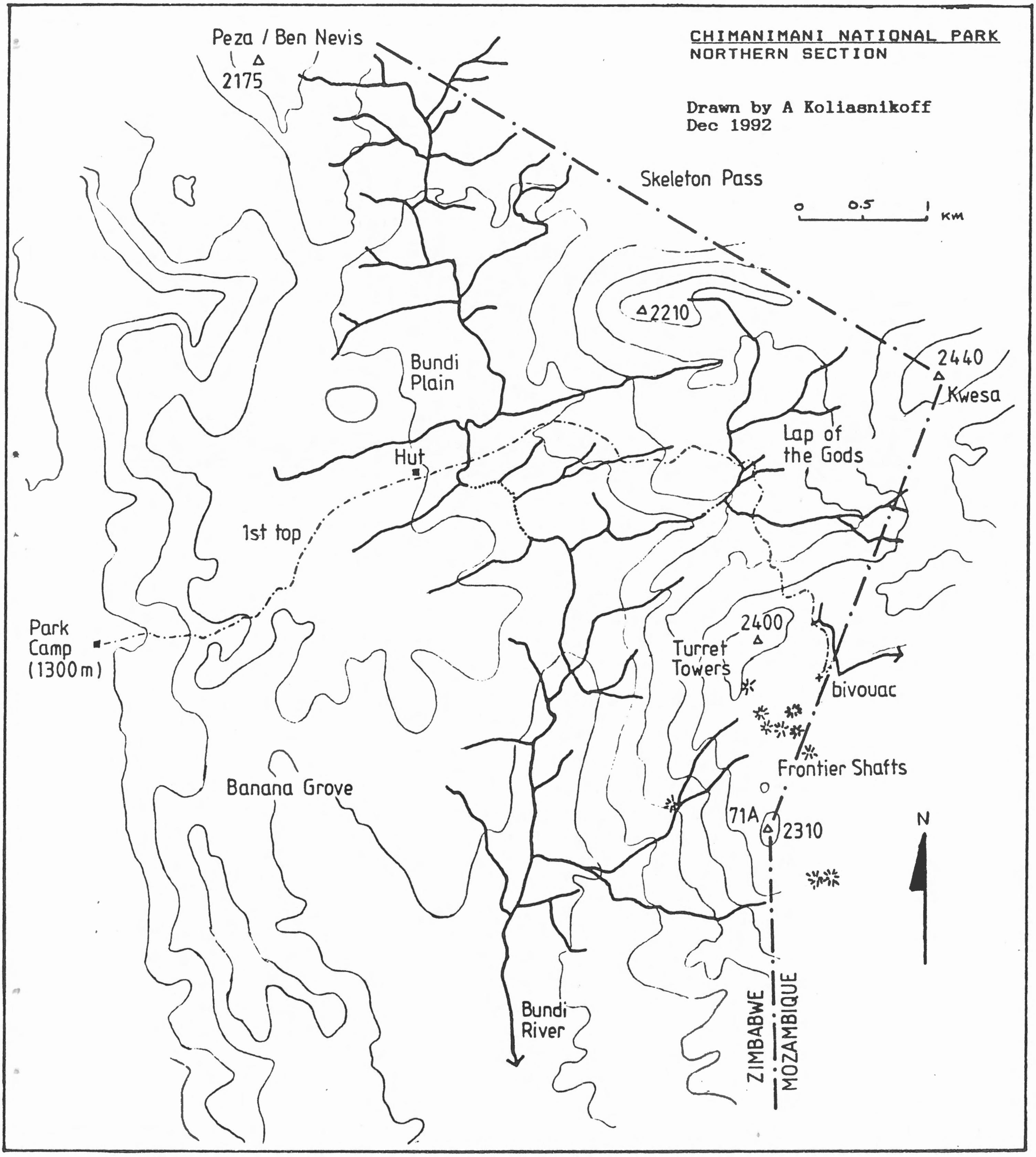
The Frontier Shafts Area:
New Surface Reconnaissance

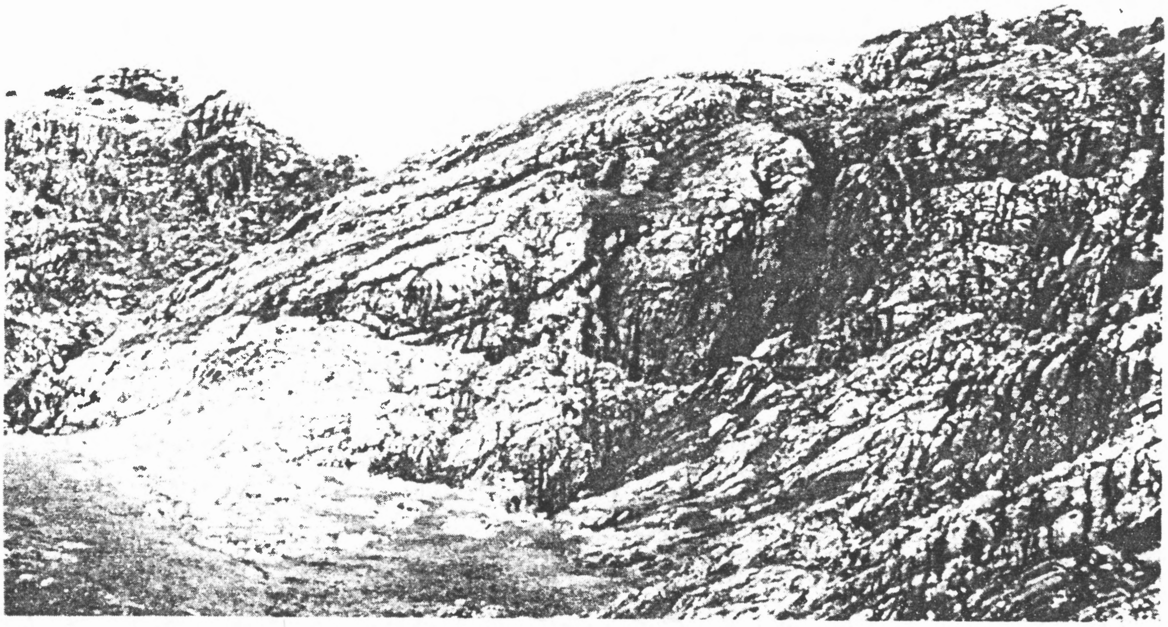
A. Koliasnikoff

The Frontier Shafts area of the Chimanimani National Park was only partially explored by the 1990 and 1992 Expeditions due to time limitations. One of the objectives of the 1993 Expedition was therefore to complete the surface reconnaissance of the area. Many hours were spent negotiating the difficult terrain in an attempt to understand the complex topography of the area. However, we only managed to inspect the main surface features, and some of the more inaccessible areas still remain unvisited. The Frontier Shafts cover an area of about 0·72 km², consisting of two main watershed zones. The eastern watershed in Mozambique contains only the M1 Doline and covers an area of about 0·28 km². The western watershed in Zimbabwe contains all the other dolines and covers an area of about 0·44 km². The two areas are divided by a ridge which coincides approximately with the upper thrust block of White Quartzites. Before the 1993 Expedition only two shafts had been bottomed; Bounding Pot (Z1) at -190 m, and Jungle Pot (Z4), then at -234 m. In addition, Black Crystal Abyss had been partly explored to a depth of -45 m, and the boulder choke at the bottom of Z3 Doline had been briefly investigated. A number of other dolines, initially numbered Z5, Z6, Z7, and Z8, had been identified but not explored.



Looking west across Mawenge Plateau, with Turret Towers rising to the right. (D.P. Ward)


CHIMANIMANI NATIONAL PARK
NORTHERN SECTION
Drawn by A Koliasnikoff
Dec 1992
Peza / Ben Nevis
2175
Skeleton Pass
0 0.5 1 KM
2210
2440
Kwesa
Bundi
Plain
Lap of
the Gods
Hut
1st top
Park
Camp
(1300m)
2400
Turret
Towers
bivouac
Frontier Shafts
71A
2310
N
Banana Grove
Bundi
River
ZIMBABWE
MOZAMBIQUE

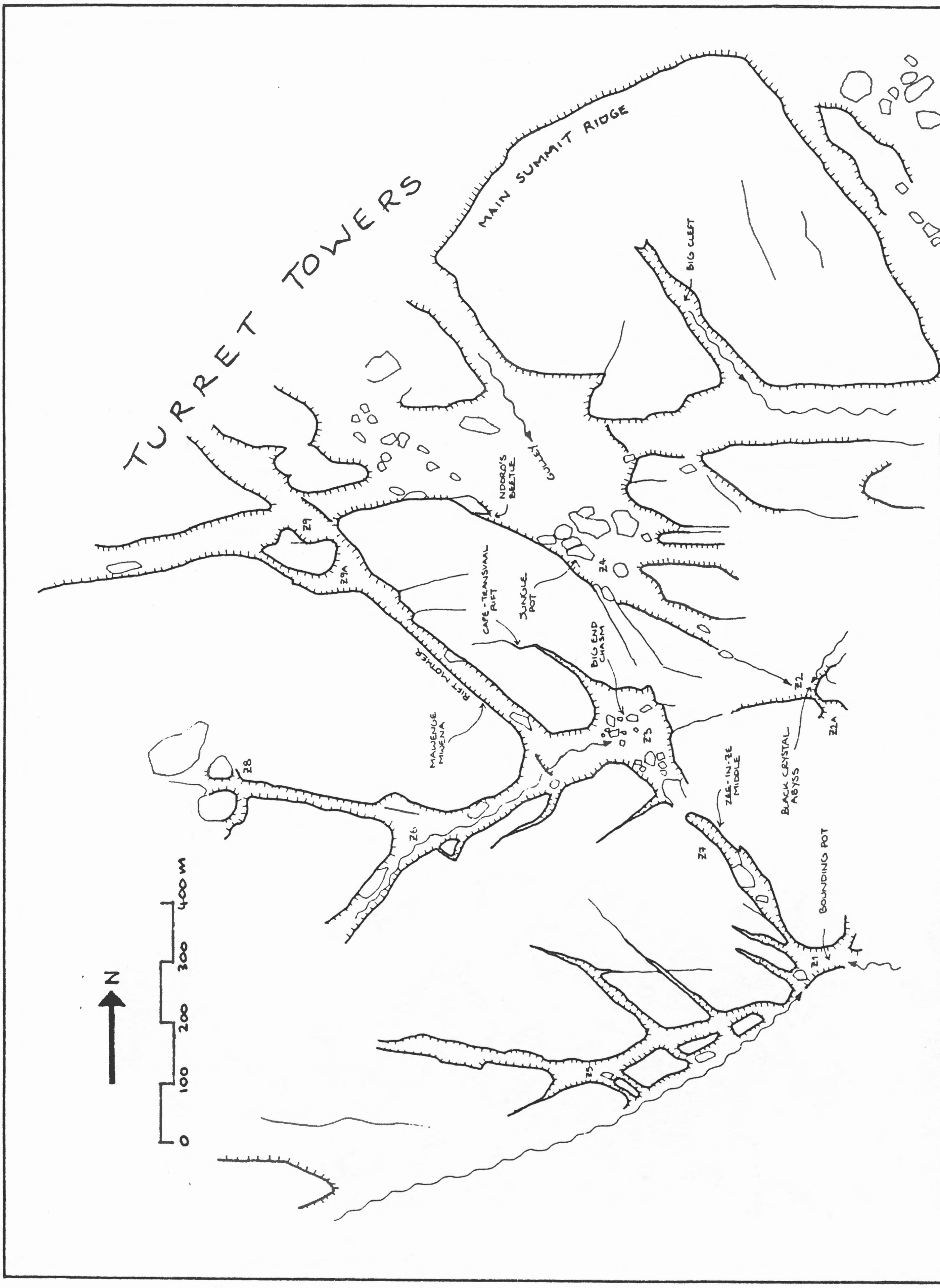


A view of the Frontier Shafts caving area in the Chimanimani National Park . (D.P. Ward)

Our initial objective of pushing the caves in Z2 and Z3 dolines was largely completed during the first week of the expedition. Black Crystal Abyss (Z2) was bottomed at -154 m and Big End Chasm (Z3) was bottomed at -150 m. A second shaft was subsequently found in Black Crystal Abyss, reaching a depth of -187 m. Later in the expedition two new dolines were discovered, Z9 and M1. Caves were found in both of these dolines: Mozpot (M1) was bottomed on the second last day of the expedition at a depth of about -90 m and Mawenge Mwena (Z9) was bottomed on the last day at a depth of -305 m. In addition, the cave identified in Z7, subsequently named Zee-in-ze-Middle, was explored to a depth of -58 m.

We had hoped that shafts would be found in dolines Z5, Z6, and Z8. Doline Z5 was explored by Le Roux and Taylor, but only a small, unsurveyed, cave was found. Z5 may conceal other possible cave entrances as it is full of thick vegetation making it difficult to negotiate. Two rifts intersect in the doline and these were briefly visited. The Z6 'Doline' is probably not a closed depression as previously thought, but only a widening where two rifts intersect. A full traverse of Z6 Rift from the upper reaches of Turret Towers to where it enters Z3 Doline should be completed. Z8 'Doline' is probably also not a closed depression, but simply the junction of two rifts.

Another disappointment was that no cave was found in the big cleft in the eastern side of the Turret Towers summit block, reconnoitred by Truluck and Holland. In 1991 it was thought that it contained a shaft, which had been prematurely named Cleft Shaft and labelled Z10. However, the recconnaisance of the caving area produced two important surprises. Firstly the M1 Doline containing Mozpot was discovered 400 m to the east of the Z1 Doline. We had previously thought that the Frontier Shafts system of rifts and dolines did not extend beyond the Z1 gulley. The stream-way in Mozpot may be hydrologically linked with the stream at the bottom of Bounding Pot (Z1). Secondly a very large rift was discovered linking into Z6 Rift. This rift, known as Z9 Rift or 'The Rift Mother', reaches a depth of over 50 m in places. Its walls consist of sheer vertical cliffs along its lower length. The upper section of the rift is intersected by two other rifts to form two large depressions. It was in the lower section of this rift

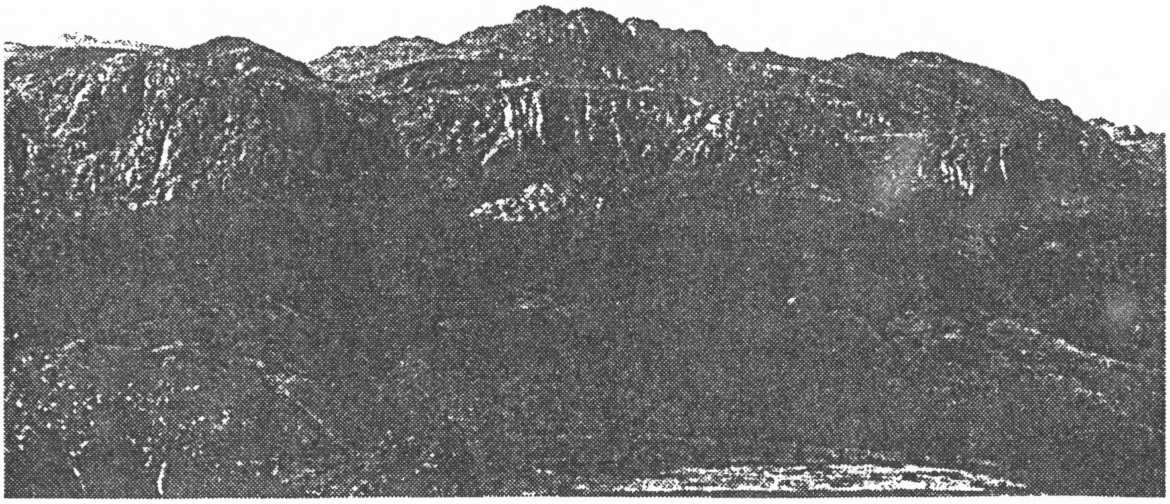


PLAN OF TURRET TOWERS CAVING AREA
Chimanimani

that Mawenge Mwena was discovered during the latter part of the expedition. Until Mawenge Mwena's discovery we were beginning to think that shafts developed only in the four major dolines (Z1 to Z4) along the north-eastern edge of the area. We had speculated that shafts may not form at higher elevations near to the summit ridge, as rainwater run-off at these levels would be insufficient for shaft development. The discovery of Mawenge Mwena caused a re-evaluation of the theory that the cave shafts form only at the junctions of the larger rifts. Speculation was reopened that shaft entrances might be discovered at higher elevations giving a greater depth potential. It is possible that closer examination of the other rifts may reveal further 'surprise' shafts hidden amongst the rifts.

The surface survey work was co-ordinated by Truluck. This included surveying the relative positions of the entrances to all the caves, so that they could be plotted in true relationship to each other. We were able to get almost instant feedback as the data were analysed using the 'Caver's Work-bench' suite of programs on an IBM PS2 notebook computer. For instance, we were able to see how the shafts compared in elevation and it soon became apparent that all the shafts seem to terminate at a similar level. We postulate that this may be due to a horizontal bedding level which interrupts shaft development. However, Mwenge Mwena seems to break through this level and has a second section of shaft below the short section of stream-way at around -190 m.

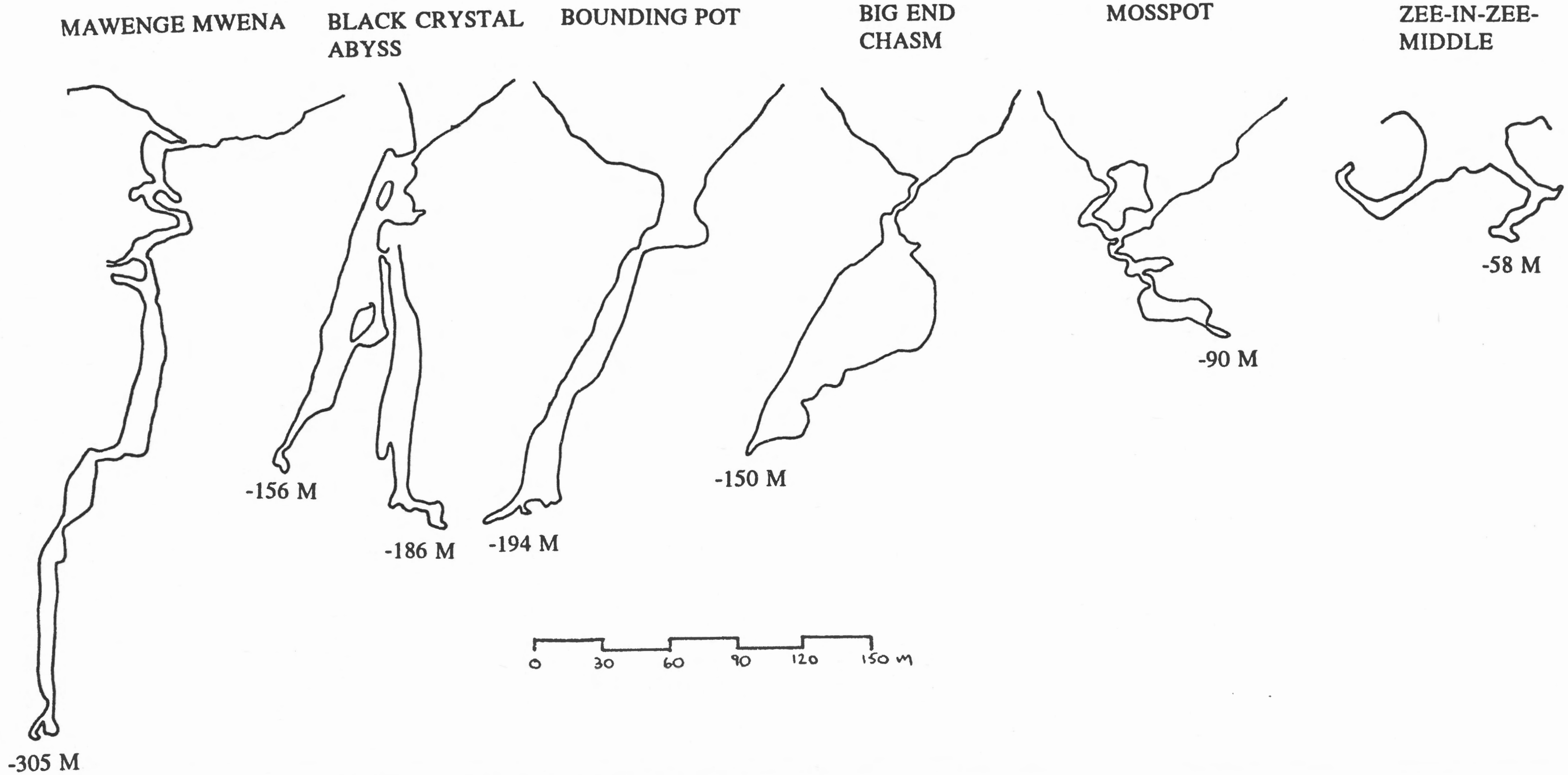
We had initially hoped that we might discover a master stream-way linking two or more shafts. We even speculated that such a stream might link to the known resurgence in the Bundi Valley. This was the motivation for the dye-test in the Bounding Pot (Z1) stream. Unfortunately, the experiment produced no positive result and the detectors placed in the resurgence stream showed no colour change. Nonetheless, a short stream passage was discovered at the bottom of the Long Drop in Black Crystal Abyss (Z2) at around -175 m, which seems to coincide with those found in Mawenge Mwena (Z9) at -190 m and Bounding Pot (Z1) at -194 m.



The grandeur of Chimanimani: A view up from the Chimanimani Park camp, across the foothills hiding the Bundi Plain, to the looming Turret Towers in the distance. (D.P. Ward)

COMPARISON OF CAVES EXPLORED IN 1993
Chimanimani

SECTIONS



Expedition Equipment and Membership

D. Harley and T.F. Truluck

A considerable amount of equipment, needing over 65 porters to carry it up Turret Towers to the Frontier Shafts camp site, was used during the 1993 Chimanimani Expedition. This section lists the most important items of equipment and comments on their usefulness. The Expedition was purposely kept relatively small, with only 16 full-time members. The emphasis was on cavers proficient in vertical, particularly Single Rope Techniques, but members specifically responsible for survey work and surface support were also included.

Communal Tent: 3 m x 3 m; weight (with poles) 30 kg; loaned by J-P Le Roux.

The communal tent was used for storing all food, cooking and electrical equipment. It had a side wall which could be opened out to form a canopy, useful for cooking while it was raining. The tent also provided a social focus for the expedition and was definitely an asset to the expedition.

Generator: Honda EM 650 (750 kW); weight 23 kg; loaned by Midmacor, Johannesburg and Cape Town.

The generator was used to charge the drill, radio and lamp batteries. It also powered fluorescent and incandescent lights in the communal tent. The abundant light certainly made the social scene at night more active than it otherwise could have been, and facilitated night work on surveys and equipment. The generator provided power at 250 V AC and 12 V DC, the 12 V source being used to power the lamp battery charger. The generator is the quietest generator of the Honda range, and proved to be very reliable, quiet, and easily carried by a single porter. It always started without any problem and worked in all weather conditions. It was usually left on at night to charge the batteries, consuming about 1 litre of petrol a day.

Radios: Two 5 W base stations and 4 hand-held units with battery chargers; loaned by Alcom, Cape Town.

The radios were used to maintain contact with teams sent out from base. Unfortunately, the mountainous terrain limited their range, although reflection off peaks sometimes allowed communication under bizarre circumstances. On the whole, they were not very useful, except during an incident in which one of the expedition members, who had gone walking, failed to return at night. The following morning a search of the Park was conducted, coordinated from the base station, which was moved from the camp site to the top of Turret Towers. This allowed communication over the entire Park, and proved invaluable. In such an emergency, a set of radios proved to be very useful.

Portable Computer: IBM PSNote 182 notebook computer; loaned by ISM, Cape Town.

The notebook computer was used to plot the survey data as it was acquired, with the aid of the 'Caver's Workbench' suite of shareware cave surveying programs. The computer and software proved their usefulness, allowing us to plot and rotate all the caves simultaneously in three dimensions, permitting excellent evaluation of the faulting in the area. The computer was also used, albeit not very successfully, for stock control. Unfortunately, the hard-drive ceased to function while up the mountain. Luckily, we had made back-ups of all our data and managed to operate the survey programmes from 1·44 MB stiffy discs.

The Land Rover and trailer that transported most of the 2·5 tons of equipment, being inspected by (l-r) Hein van Huyssteen, Richard Mitchell, Lisa Casalvolone and Pete Aucamp. (T.F. Truluck)

Cooking Equipment: Two paraffin pressure stoves, two large pots, one 25 litre water container, utensils; purchased by the expedition.

The stoves proved to be ideal for cooking the staple meals of texturised vegetable protein (TVP) and rice, causing few problems. The 25 litres of paraffin carried up was only half consumed by the time we left, 28 days later. Despite its bulk, the water container was worth carrying up, as it eliminated the need to tramp down to the river every time someone needed water.

Toilets: Two milk crates with toilet seats attached, a bag of lime, one spray bottle filled with 'Dettol' antiseptic; purchased by the expedition.

Although the proposal that these items be added to the equipment list was greeted with much mirth and incredulity, they were universally appreciated. Dave Ward attached toilet seats to the milk crates which were placed in separate locations above 50 cm deep pits. Lime was scattered in the pits each day, together with some sand. When each pit became half-full, it was filled and the toilet relocated. Users, especially if handling food, were expected to spray their hands with Dettol when finished. No case of serious food-poisoning occurred. A latrine pit filled with rocks was constructed for the male members of the expedition. These facilities were much admired, and enjoyed, by all our visitors.

12 Station Battery Charger: Most components were purchased by the expedition; headlamp terminals were donated by First National Battery, Johannesburg; David Harley designed and constructed the charger.

This charger was custom-built to operate off the 12 V, 10 Amp DC supply from the generator. Unfortunately the unstabilised output from the generator caused havoc with the electronics of the charger, which only worked satisfactorily when the power supply was smoothed using three batteries in parallel, which was not very satisfactory.

First Aid Box and Stretcher: First-aid box loaned by Ms Jenny Stern, Cape Town; the stretcher is the property of SASA (Cape).

A first aid box and stretcher were kept in the communal tent. Fortunately, no major accident occurred, but the first aid box was used to treat various cuts and abrasions. Although the stretcher was awkward to carry, it was useful as a container for other long items that had to be carried up the mountain. Fortunately, it was also not used, but it would certainly have been essential for transporting any seriously injured caver.

Hilti TE-10A Hammer Drills, Battery Chargers, Battery Packs and Bolts: Loaned by Hilti Fastening Systems, Cape Town and Johannesburg.

Two Hilti TE-10A hammer drills were used for drilling holes for all bolts used in rigging the caves. Their use is described and evaluated in detail in the drill evaluation report.

EXPEDITION MEMBERS

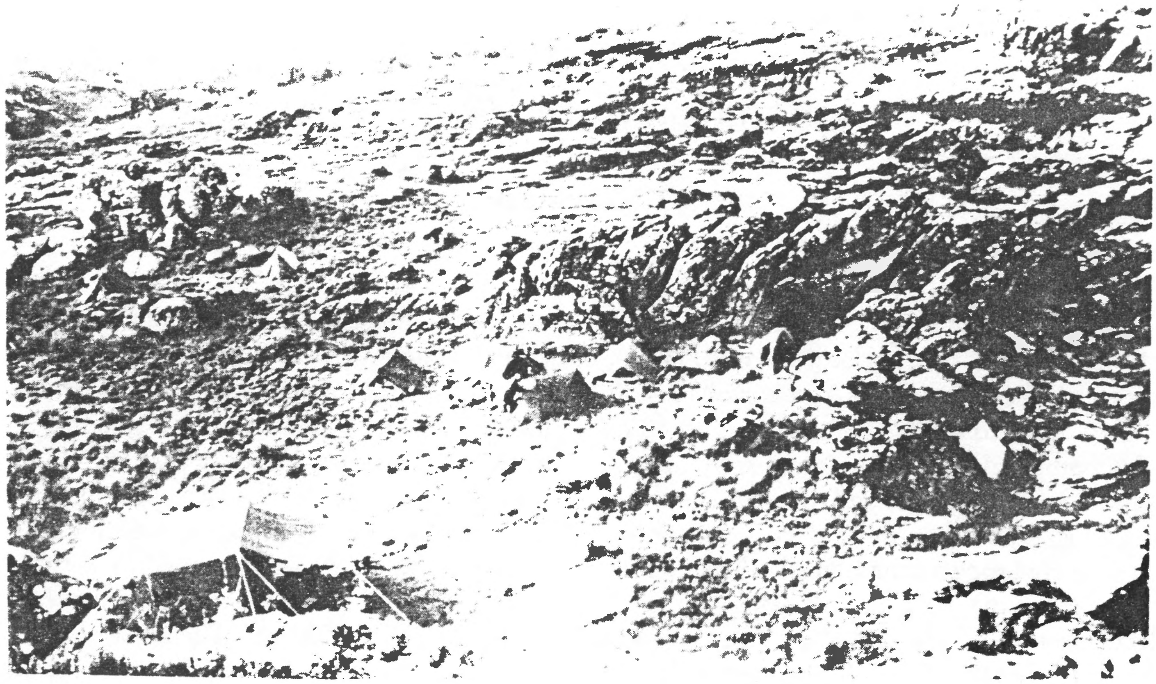
Leader: J-P Le Roux **Secretary:** Tim Truluck

Cavers: Pete Aucamp, David Harley, Darryl Holland, Alistair Koliasnikoff, Stuart Page, Kenda Taylor, Dave Ward

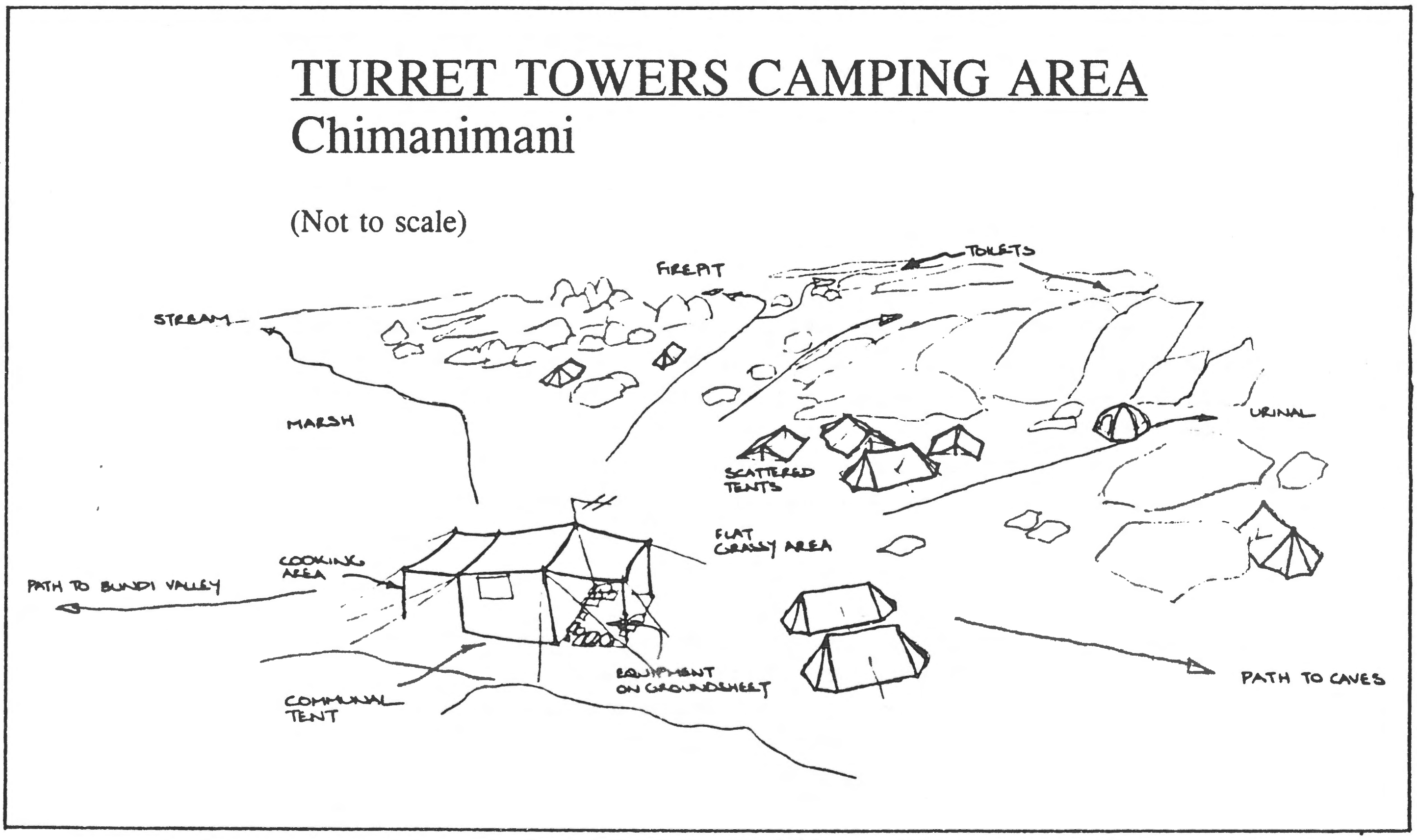
Surface Support: Lisa Casalvolone, John Grindley

Zimbabwe Mountain Club: Robert Battersby, Ellen Broome, Jeff Broom, Jane Dobney, Jonathan Timberlake

The Caving Team. Back row: Darryl Holland, Dave Harley, Lisa Casalvolone, Pete Aucamp. Middle row: Dave Ward, J-P le Roux, Kenda Taylor, Stuart Page, Tim Truluck. Front row: Alistair Koliasnikoff, Nicholas Ngwenya (Zimbabwe National Parks), John Grindley.



An overview of the main campsite on Mawenge Plateau on the fourth day. (T.F. Truluck)



Sketch of the layout of the main campsite on Mawenge Plateau.

Black Crystal Abyss (Z2): Exploration of the Main Shaft

T.F. Truluck

Black Crystal Abyss was visited on the 1991 SASA (Transvaal) trip (Le Roux *et al*, 1993), during which Dick Howell and Alistair Koliasnikoff scrambled down to a ledge before abseiling 18 m to a flat bottomed chamber subsequently named "Brighton Beach". At one end, they encountered a pile of loose boulders and a deep drop, down which a lowered rope reached about -35 m. Before they returned to the surface, Howell found a small black cube on "Brighton Beach" and the cave was named Black Crystal Abyss[1]. The entrance shaft is located at the base of a cliff in a lower doline to the east of the huge Z3 Doline containing Big End Chasm. The smaller Z2A Doline, under which lies the main shaft of Black Crystal Abyss, entered via the Z2 Doline, lies to the south. A steep slope leads to the north before dropping into the Z4 Doline containing Jungle Pot. The apex of the slope between Z2 and Z4 Dolines forms an easy access point to Jungle Pot. This apex decreases the lowest known point of the Z4 Doline, reducing the depth of Jungle Pot to -221 m. The exploration of the main shaft in Black Crystal Abyss is recalled in exerpts from the exploration diary:

Friday 6 August 1993

After breakfast Dave Harley, Alistair Koliasnikoff and Kenda Taylor went to explore and survey in the Z3 doline. Dave Ward and John Grindley walked to the top of Turret Towers. Darryl Holland and I started the survey of the Z2 and Z2A dolines while Pete Aucamp and J-P Le Roux sorted out caving gear and bolts in preparation for the exploration of Black Crystal Abyss. Holland and I soon finished the Z2 and Z2A Doline survey and noted a small hole in Z2A which needs further investigation. We were joined by Aucamp and Le Roux who began rigging Black Crystal Abyss.

In Black Crystal Abyss we descended through a series of pitches, passing "Brighton Beach", down a 40 m pitch to a ledge in the main shaft called "Not-a-Ballroom", before finally ending up in a small chamber 15 m below "Not a Ballroom" (-90 m). I collected two beetles in a pool and noted a tadpole. Two other crustaceans were found overlooking the 40 m pitch at "Brighton Beach". Two small grey bats were noted in the nether recesses of Brighton Beach Chamber. We started the ascent at around 20h00. Holland struggled a bit near the entrance as he was exhausted because he had not taken food into the cave with him.

Saturday 7 August 1993

Two teams of cavers are emerging. Aucamp/Le Roux and Koliasnikoff/Harley, also known as the Keen-Lean Team. The Keen-Lean Team is first up and ready to go caving before 10h00. The other team takes about four hours to get going and usually only return after dark between 21h00 and 22h00. Holland, Dave Ward and I can be attached and detached at will. Kenda Taylor is a bit unsure of herself and lacks confidence to do anything new and untested.

1. The cube was subsequently lost, and the 1993 Chimanimani Caving Expedition found no cubes in this cave. However, several were collected in Mawenge Mwena and Big End Chasm, and were identified as a polymorph of iron pyrites.

Darryl Holland (top) and Kenda Taylor (bottom) in "Not-a-Ballroom" in Black Crystal Abyss. (T.F. Truluck)

Le Roux, Aucamp, Holland, Taylor and I went down to "Not a Ballroom" in Black Crystal at about 12h00. We all waited while Aucamp rigged the descent. After 1½ hours, Taylor returned to the surface. The rest of us waited for another 1½ hours before Le Roux got the go-ahead from Aucamp to descend. Le Roux took ages to get over the lip as there was a very difficult take-off in a crack to a free-hanging change-over under a boulder. Two rub-points developed while Le Roux was struggling to negotiate this nasty section.

Meanwhile Holland and I were very cold. We were in no mood to follow the others down. We passed the end of the tape to Le Roux and then to Aucamp at the bottom. It measured 49 m at an angle of 70° (depth of -146 m). I then left the cave, leaving Holland to ensure that the rub-points did not get worse when the others ascended. My descent and ascent today were much smoother than yesterday - I did not get into so many tangles. I reached the top at 19h00 and ate my biltong and Mars Bars while waiting for the others. After 45 minutes I returned to camp. Casalvolone and Taylor cooked supper. The others eventually returned at 21h30.

Sunday 8 August 1993

The "Keen-Team" is slowing down. They eventually left the camp site at about 10h00. Le Roux and Aucamp are still "Slow to Go" and only left for Black Crystal Abyss at about 12h00. After yesterday's wait in the cave, Holland and I were not keen to survey at the same time as Le Roux and Aucamp. We decided to conduct a surface survey between the known lower dolines. Casalvolone and Taylor accompanied us. We linked Black Crystal Abyss (Z2) with Jungle Pot (Z4) via Dirk's Hole and took the girls down to the archway in the Jungle Pot Doline. Holland and I investigated the doline from the south end via the Black Crystal Abyss Doline. There is a distinct path into the doline from this side and it leads to a blowing hole about 15 m from the Jungle Pot entrance. We then linked Z3 with Z7, and Z2A with Bounding Pot (Z1).

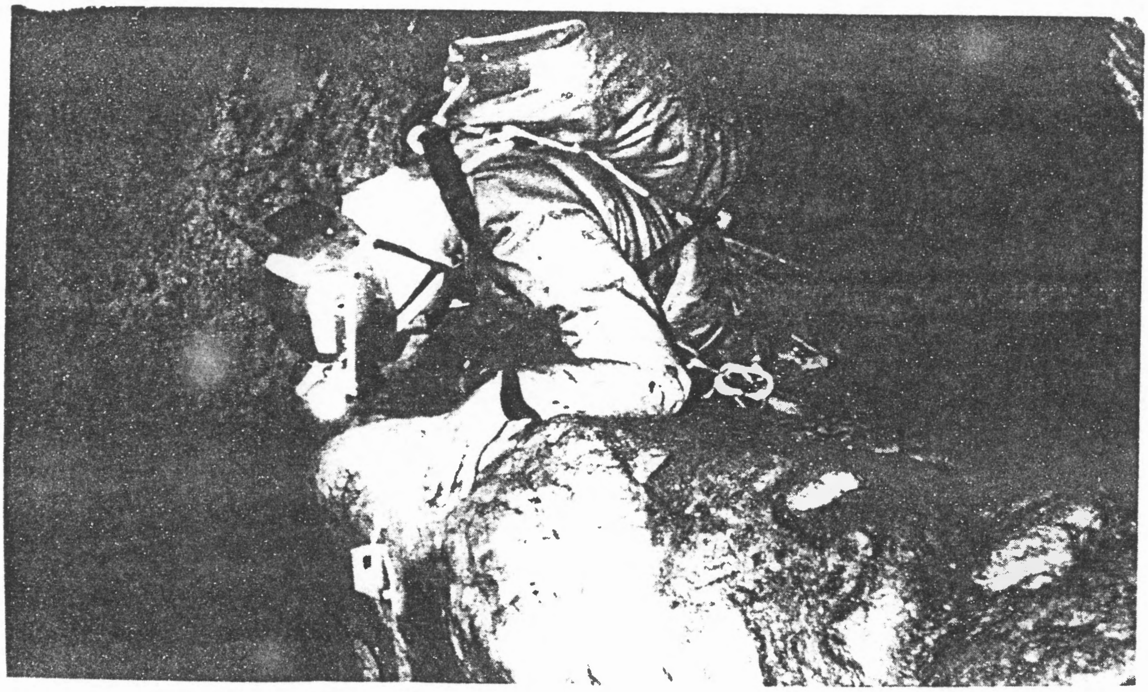
We returned to the camp site at about 13h30. Dave Ward and John Grindley had returned after walking up Binga. Ward then kitted up and joined the "Keen-Team" in Z3. Meanwhile I put the surface survey data into the computer and spent a frustrating 3 hours trying to make sense of the data. Jonathan Timberlake, Jeff and Ellen Broome (Zimbabwe Mountain Club) arrived in mid-afternoon. After exploring Cleft Shaft (Z10) Holland and I returned to the camp site at 19h30 and cooked supper (soya and rice again) while chatting to the new arrivals. The cavers were late this evening: Le Roux and Aucamp returned at 21h30 and the Z3 team at 22h30. Both teams reported that their respective caves had terminated. At the bottom of the 46 m pitch in Black Crystal Abyss there is a flattish rock strewn section with pools of water. A blind frog and a few beetles were collected. This section of the cave was named "Toad Hall" in honour of the frog. Leading off from the bottom was a narrow rift which descended for about 20 m before becoming too tight (at -156 m).

Z3 has a big chamber, named Hecate's Crack, at the bottom. They are still not sure how long the pitch is as they only had a 30 m tape. They think the cave bottoms at about -143 m but it could be up to 10 m longer when the pitch is measured. It has two long pitches with lots of good rock. Koliasnikoff found a lead at the bottom which he still wants to push. They have named it Big End Chasm.

Monday 9 August 1993

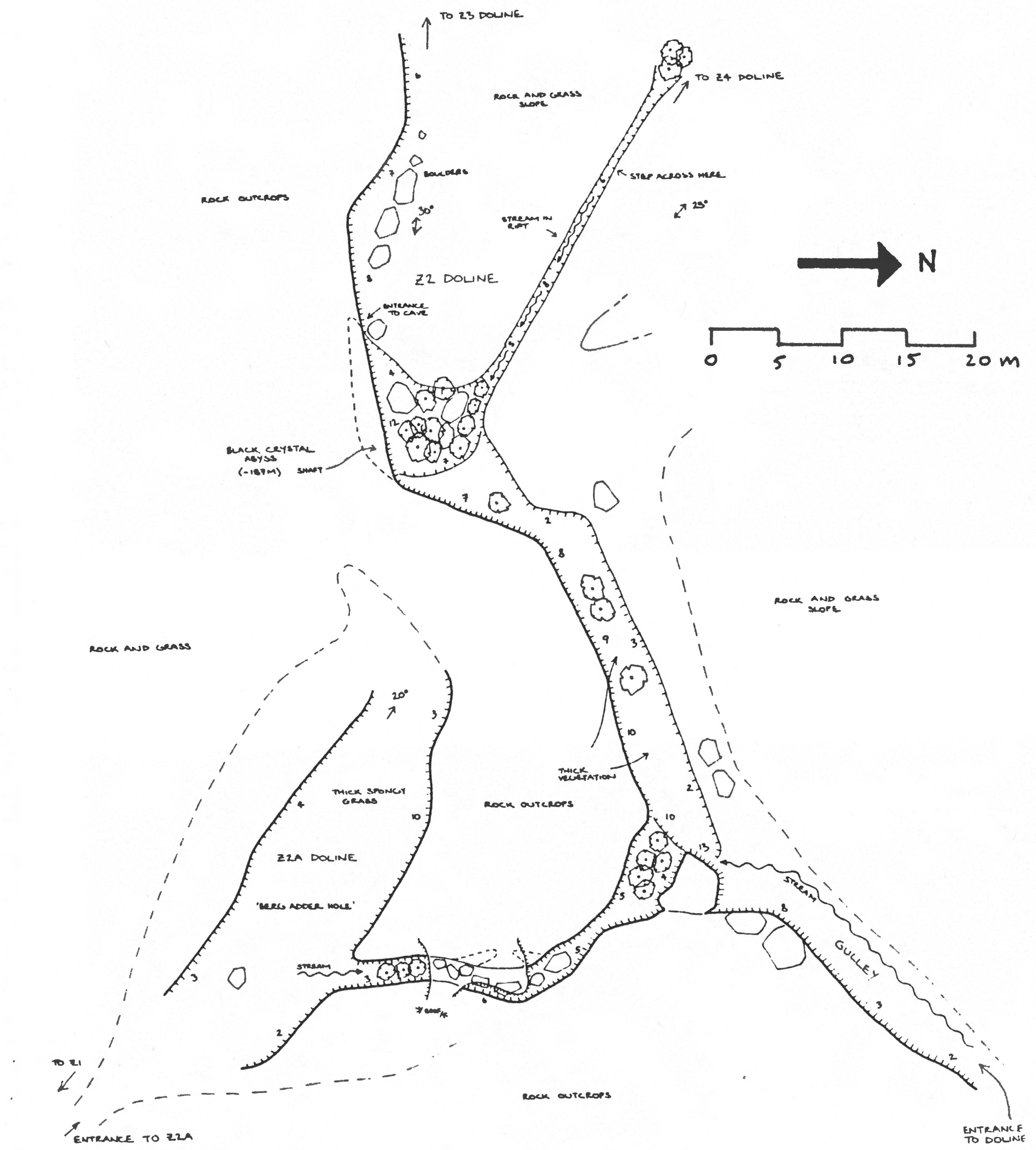
Lazy day for most of the cavers. At about 12h00 Holland, Taylor, Ward and I returned to Black Crystal Abyss to finish the survey. After all of us descended to "Not a Ballroom", Ward and Holland continued to the bottom. Taylor followed, but had problems with Aucamp's rigging. Her light also started to fade and she returned to "Not a Ballroom". I had to help her over the nasty take-off and decided to leave the cave ahead of her so that I could abseil down and assist her if needed. Meanwhile Ward and Holland completed the survey at the bottom.

Taylor and I safely reached the surface at 19h00 and returned to the camp site. The others returned at 21h00 after de-rigging the lower section in the narrow rift and completing the survey. Earlier Aucamp had cut his thumb down to the bone while changing a sparkplug on the Honda generator. He will probably be out of commission for a few days. Supper was cooked by Harley and it was very tasty - almost all the soya was eaten. The cave which had seemed very promising bottomed out in the main shaft at -156 m. However, during the de-rigging of the cave, Harley and Le Roux, investigated a blowing hole about 15 m below "Brighton Beach".



J-P le Roux prepares to descend 50 m to "Toad Hall" in Black Crystal Abyss. (T.F. Truluck)

Pete Aucamp drilling in the crack in "Toad Hall" leading to the bottom of the first shaft in Black Crystal Abyss. (T.F. Truluck)



Z2 AND Z2A DOLINES
Chimanimani

The Long Drop

D. Harley

During the initial exploration of Black Crystal Abyss by Pete Aucamp and J-P Le Roux, a blowing hole located about 15 m below Brighton Beach was noted. The de-rigging team, consisting of Alistair Koliasnikoff and I, was asked to investigate the hole before completing the de-rig of the cave. We subsequently de-rigged the cave up to the hole, which I investigated. I found it to slope steeply down about 10 m before ending in a narrow vertical crack. When a rock was tossed down the hole it rattled around for 7 seconds before hitting bottom. The top squeeze looked forbidding and it was obviously a big rigging job, so the hole was abandoned until another day.

A few days later I returned with Le Roux. After re-rigging the entrance pitch to the hole, I began the pitch with an 80 m rope, putting a Y-hang into the crack with deep-set Rawl Bolts. The rock was so rotten that the second bolt cracked the rock as it was tightened. Once a satisfactory hang was obtained I had to slip sideways into the crack and descended at a thirty degree angle for about four metres, before coming to the next re-belay point. Unfortunately the Rawl Bolt drill bit was too long to fit into the crack. After one abortive attempt I decided I would have to put in two HKD's (Hilti stainless steel cone-anchor bolts, used when the rock is hard) instead; the rock was quite hard at that point anyway. Their placement required a considerable amount of exhausting gymnastics. Le Roux did not improve matters by commenting that the performance would have produced some wonderful photographs, only he did not have a camera.

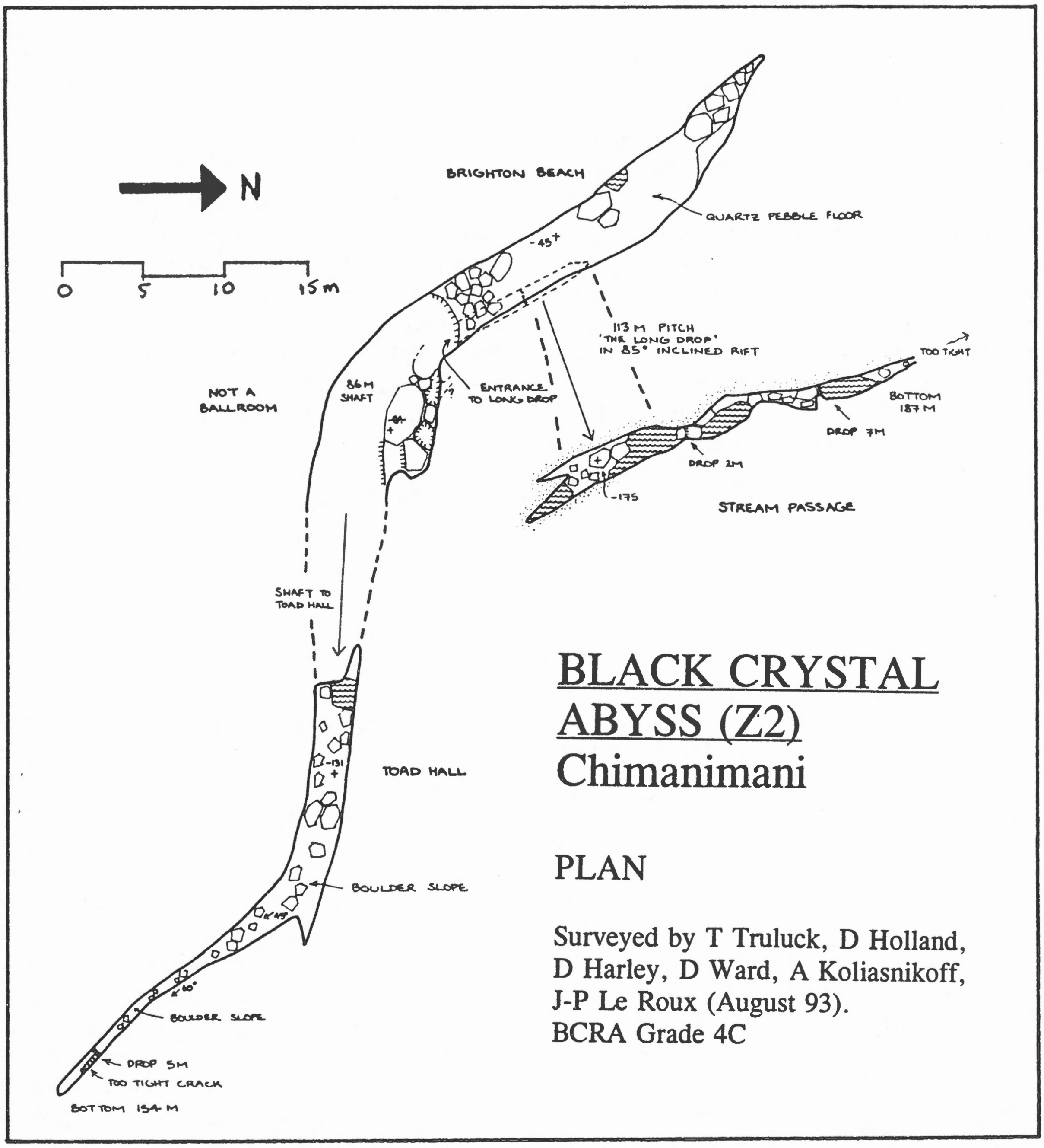
After the second Y-hang was placed, progress was quite rapid. The crack widened to about 1-2 metres and descended at an angle of about 80 degrees. The drill battery gave out at the first deviation, and Le Roux had the bright idea of lowering the second battery to me on the survey tape. In that situation it worked, but after that I always carried the spare battery with the rigging kit. A couple of re-belays and deviations later, the crack widened out further and a large spire of rock appeared. There was a nice free-hang next to the spire, and I could not see the bottom. Until that point, the fissure was almost perfectly smooth and unbroken, and one was nearly always against the wall. I descended past the spire for about 15 metres, when the rope ran out. The only thing to do was to pack up for the day and come back with another rope. I found Le Roux at the top of the pitch, where he had remained the whole time cuddling his carbide generator and consuming a large stock of biltong. I asked him why he had not come down, and he informed me that he had been waiting for me to tell him that the rope was free. How remiss of me.

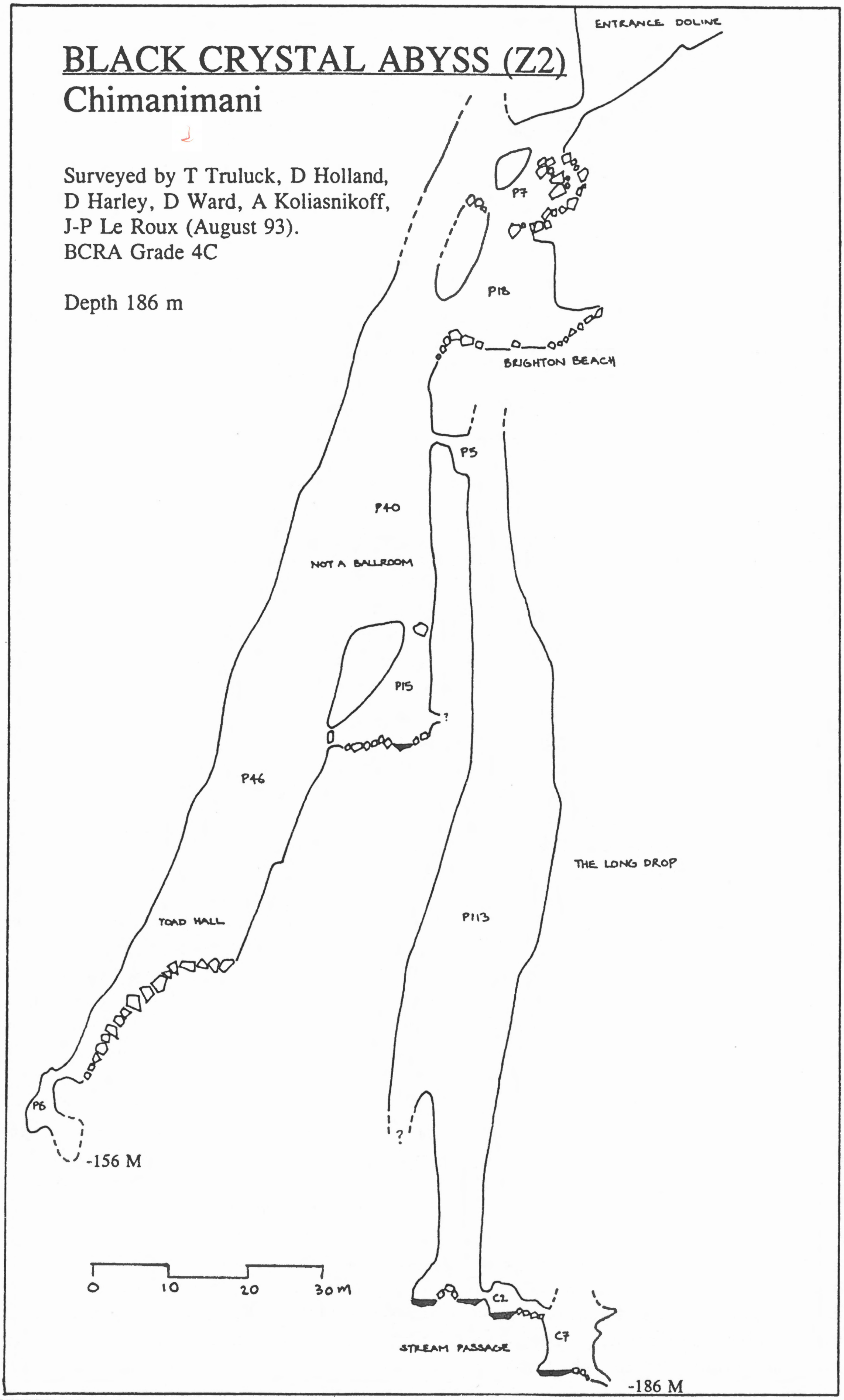
The next time I returned with Koliasnikoff, who had returned from a re-supply mission down the mountain. I descended and added extra deviations to remove two rub-points I had noticed while prussiking up on the previous trip. After reaching the spire, I found that just one deviation and a re-belay were required to reach the bottom. The last deviation was named the Picnic Spot by Koliasnikoff, as it was the only place in the pitch where there was a narrow ledge on which to sit. He had been having trouble with his harness, and was particularly appreciative of this concession in what was otherwise an entirely in-harness pitch.

The bottom turned out to be a stream bed. A few metres upstream, in the direction of the main Black Crystal Abyss pitch, the stream sumped. Downstream, it cascaded down a narrow crack in a series of terraced pools. We followed the stream for about 30 metres, at which point it disappeared into a narrow crack choked with rocks. We poked around a bit before deciding that we would have to return with a crowbar to make any progress. Shortly before we ascended, Koliasnikoff began to have trouble with his bowels, and was compelled to oblige the call of nature in a corner at the bottom of the pitch. Hence the name, Long Drop, and the unofficial name of the bottom, 'Crapper Corner'. It was not Koliasnikoff's day. He was still having trouble with his harness, and he ascended to the Picnic Spot with noises akin to someone experiencing an acute orgasm.

Two days later we returned on a push plus de-rig mission, armed with a crowbar. Koliasnikoff went straight to the bottom to dig, and I followed with the drill, drilling holes and inserting resin ampoules for resin bolts at each re-belay. The idea was that when we came to de-rig, Koliasnikoff would go in front and insert the resin bolts for the permanent rig, while I followed and de-rigged, removing the Rawl Bolts that had been used for the temporary rig. This would keep us both busy and avoid the swapping around of drill bits and setting tools that usually slowed things down. The system worked very well.

By the time I reached the bottom, Koliasnikoff had removed the offending rocks in the crack and had found it to be far to narrow to follow. He had also dug a hole in the stream bed, in the hope that it was a false bottom, but despite his remarkable and usually correct intuition in locating new passages, the stream bed was solid. The general trend of the entire crack seemed to be a closing down at all levels to a width of about 10 cm, and it is quite probable that there is no way on. The final surveyed depth of long drop was 113 m, with the bottom of the cave 186 m below the entrance of Black Crystal Abyss.





Black Crystal Abyss (Z2): The Long Drop

Big End Chasm (Z3)

D. Harley

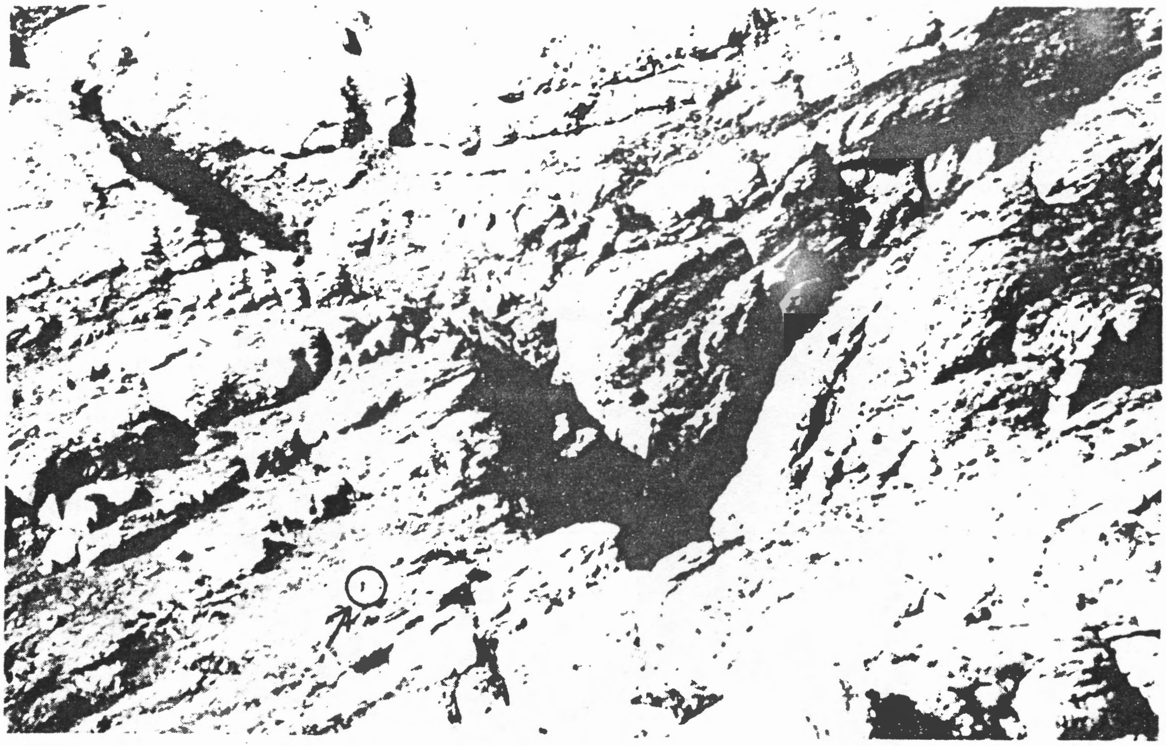
On Friday, 6 August, Alistair Koliasnikoff, Kenda Taylor and I examined the Z3 doline. Taylor and I surveyed down into the south-west side of the doline, following Koliasnikoff who had managed to hack a path to the bottom with a panga (machete). A brief reconnaissance of the bottom showed that the only promising way on was through a boulder choke against the north wall, between the water-fall on the north-west face and the Cape-Transvaal Rift, which is accessible through a small hole and a squeeze from the doline. After some scrabbling around Koliasnikoff managed to find a way down onto a ledge overlooking a chamber, requiring a rope or ladder to proceed.

We broke for lunch, and Koliasnikoff and I returned that afternoon with a rigging kit. Koliasnikoff drilled the first hole, at which point we discovered that the bolts we had were too long for the HKD anchors (Hilti stainless steel cone-anchors). The rock in the cave was excellent, and apart from a few stud bolts the HKD bolts were the only ones we had brought. This was the first time we had used the new rigging gear and we expected problems, but this was infuriating. We decided to do the first pitch with a ladder instead, and I belayed Koliasnikoff down a ladder rigged off a boulder. We found the pitch to be fairly short, and I followed. The chamber below sloped down to a second short pitch, and Koliasnikoff was preparing to rig it off the ladder and a natural belay. At this point, however, my light began to fail, and since Koliasnikoff was also on his reserve light, and it was late anyway, we decided to abort the descent.

The following day we returned with what we hoped was a functional bolting kit. We had placed nuts on the bolts to shorten them. Koliasnikoff disappeared straight down the ladder with all the rope, and I was a bit peeved because I felt that we should be doing a more systematic job of rigging. I completed the previous day's bolt and added a backup, re-rigged the ladder off the bolts, and went down to join Koliasnikoff. He had just gone down the second pitch, and I descended to join him. We were joined by Dave Ward, who had managed to find his own way down. I privately did not approve of him coming down by himself, and an irritating drip of water had just dribbled down my neck. These things combined to put me in a very irritable mood. I vented my spleen by griping at Koliasnikoff about how we were wasting time and resources, and stomped off to look around what was subsequently named the "Chamber of the Lost Provita", commemorating an incident in which we lost an important part of lunch, a Provita biscuit.

I found two cracks, on opposite sides of the chamber, that seemed to go down a long way. Only one was large enough to enter, although the access was inconvenient. I spent half an hour trying to find a better access point, crawling through several small holes. The place was a complete maze, and although I somehow found a way up to the top of the second pitch, I could not find any other access to the big chamber below. By this stage I was feeling somewhat guilty at leaving Koliasnikoff and Ward to do all the surveying, but the opportunity to rig down into an apparently bottomless pit was too good to miss.

The access was very awkward, beginning through a squeeze, followed by a short traverse to a ledge on the opposite wall. Below the ledge was a short drop of about 6 m to another ledge, and beyond that appeared to be a vertical pitch of uncertain depth. The rock was exceptionally hard, consisting of almost pure quartz, and even with the hammer drill it took some time to insert the first four bolts. I dropped down to the lower ledge and was just putting in a deviation to drop the rope straight down the main pitch when the drill suddenly



An overview of Z3 Doline, with a caver indicated for scale. (D.P. Ward)

failed; it refused to operate on anything but slow speed. I had just changed batteries and after much cursing concluded that the reserve battery must have been flat.

Koliasnikoff appeared above me and I explained the situation. The far wall was about 10 m away and despite the use of a very powerful halogen lamp, below me I could see only blackness, with just a faint glimmer from a pool of water at what was presumably the bottom. The chamber had an enormous echo and I did not want to stop then. I could not find a natural deviation point, and we decided to go down on rope protectors. I found that three rope protectors were required in the first 15 m before obtaining a free-hang. The rope was clean and new, and slithered through my rack at a disconcerting rate, but the puddle of water did not seem to get any closer.

Eventually I hit bottom, and went off to investigate the chamber while waiting for Koliasnikoff to descend. It was very steeply sloped, about 10 m wide and 30 m long, before reaching another pitch near the base. I returned to the rope and discovered that Koliasnikoff had not yet descended. He shouted to me that an extra rope protector was required, and that the others had moved down the rope. The rope protectors were new and had been threaded with cord that appeared to be too thick, and the prusik knots were slipping. He decided it would not be safe for him to abseil, and after repositioning the rope protectors, he returned to the pitch head.

I turned off my light and watched a tiny speck of light for what seemed a very long time. The light changed form and looked like a ghost hovering above me. After a while I became very cold and inquired as to 'WHAT WAS GOING ON'? I was told to `hang on'. Echoing from above I could hear a continuous and muted mutter between Koliasnikoff and Ward, and after another 10 minutes I demanded an explanation. Koliasnikoff let me know in no uncertain terms that he was stuck in the hole and that he was not enjoying himself, and when the echoes died away I could hear the continuing mutter.

By this point I was freezing, and tried to find a place out of the draught that seemed to be descending from the top end of the chamber. I sat growling to myself for several minutes and the expression 'as cold as a witch's tit' came to mind, suggesting the

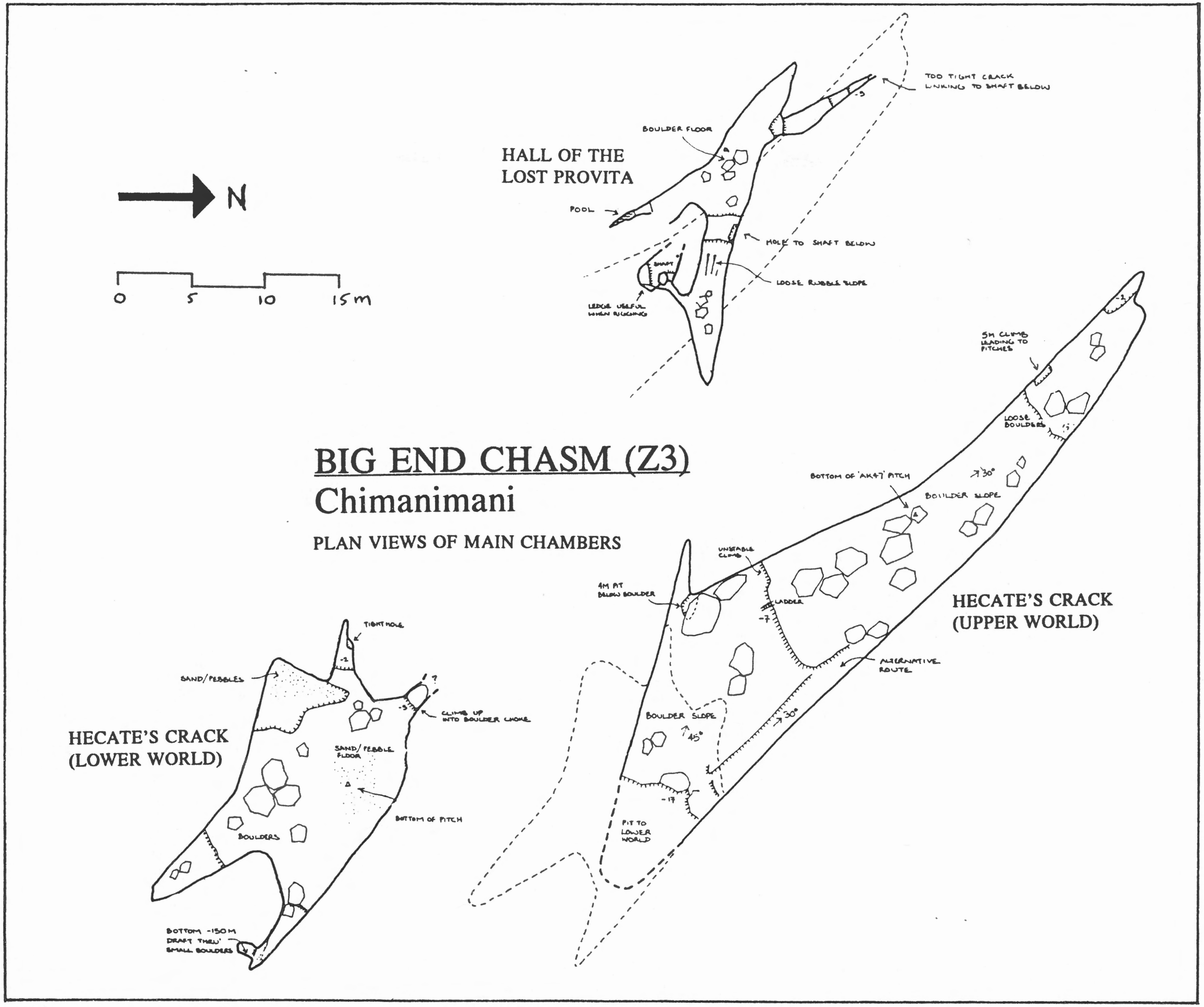
name "Hecate's Crack" for this huge chamber. Eventually Koliasnikoff extricated himself from the hole and I began to prussik up on tip-toe, worried that the rope protectors had moved again. When I finally came within 10 m of the bottom rope protector I saw to my horror that it had slid several metres down the rope, and that the rope was rubbing badly against the rock. After balancing the risk of prussiking another 10 metres, against the risk of going down again and freezing for a couple of hours while someone went back for a fresh drill battery, I decided I would rather die warm than cold, and continued the ascent.

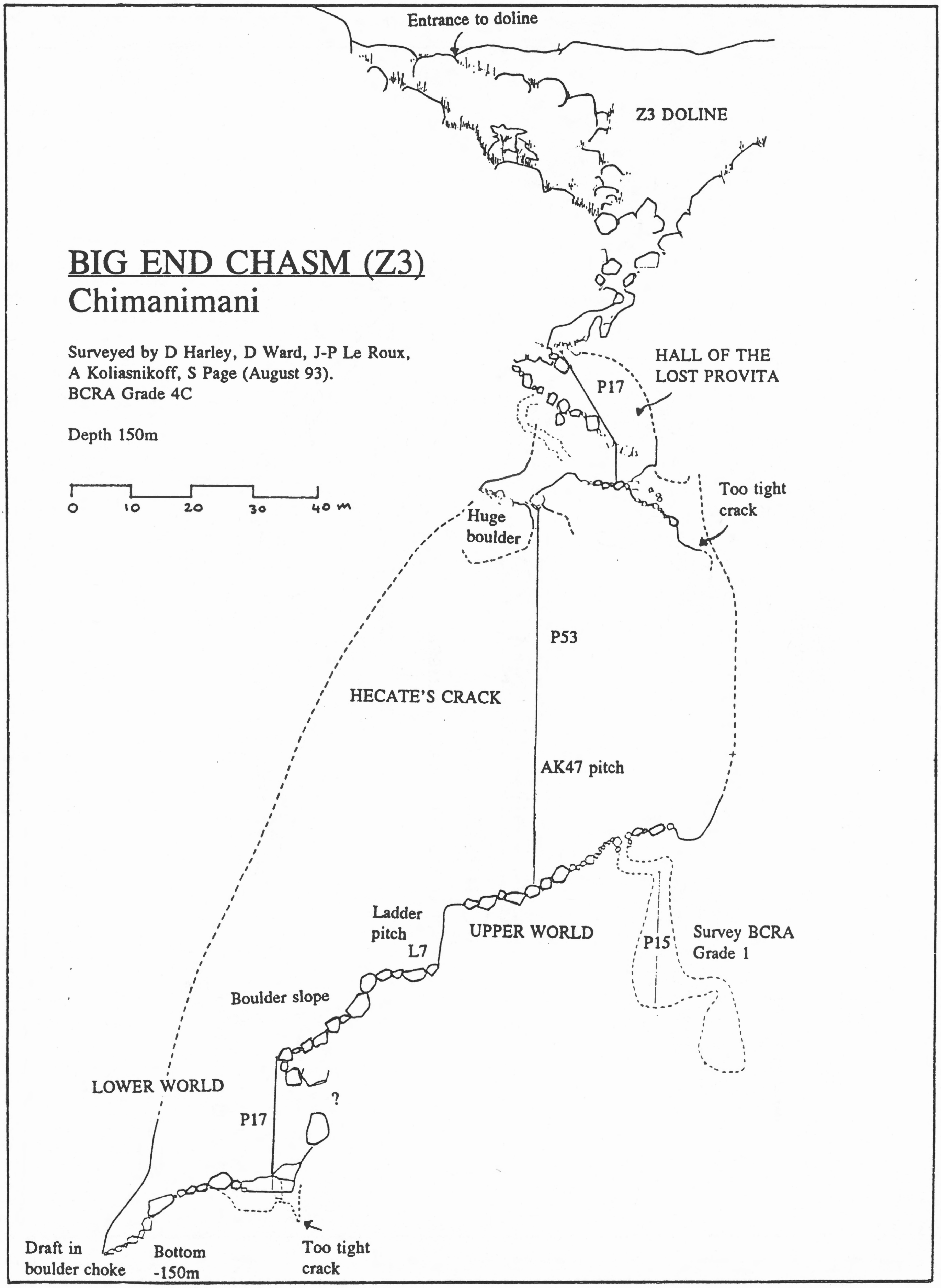
I found that the rub point was very smooth and that the rope had acquired only a slight furriness. The other rope protectors were also in the wrong positions, but again we had been lucky with the smoothness of the rock. The two lessons learnt from this particular incident were to watch that you do not do something stupid when the drill fails; and if you use a rope protector where you should use a deviation, then you are being stupid. We returned to camp and complained about the drill. Pete Aucamp told us that he had had a similar problem, and had discovered that the cause was a bad connection between the battery and the drill. We found that this was indeed the case, and with a bit of tweaking the drill roared to life.

Dave Ward in "Hecate's Crack" in Big End Chasm. (T. Truluck)

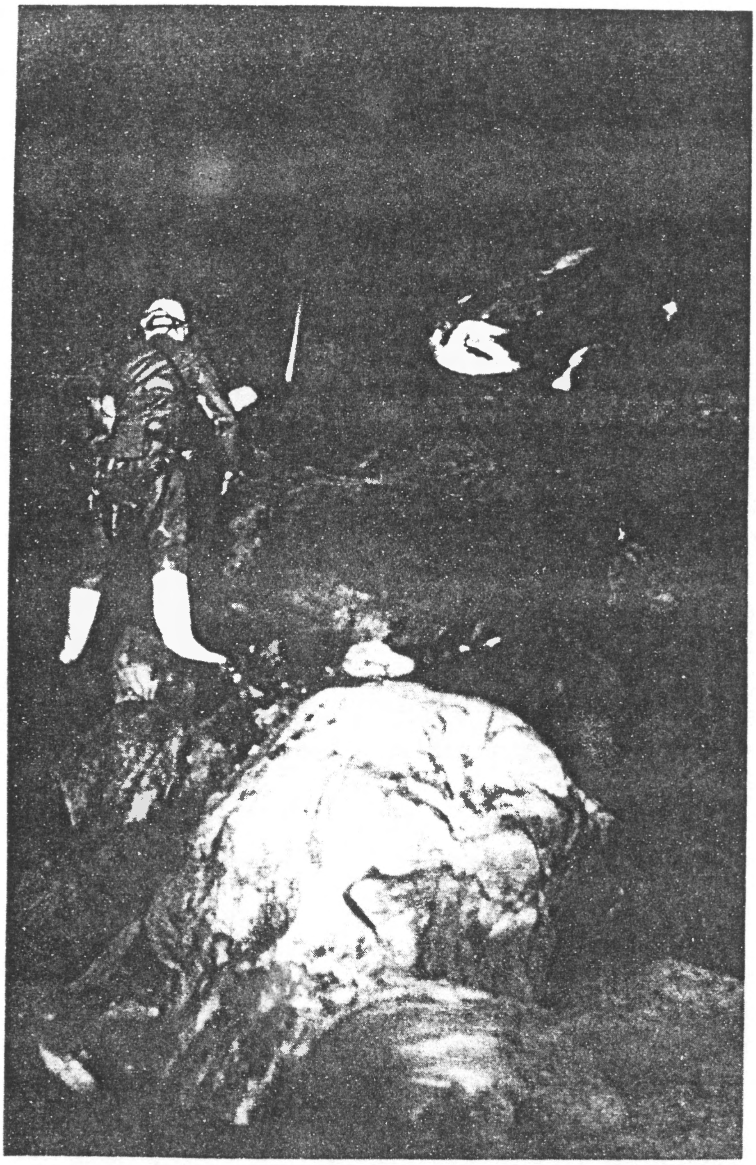
The next day Koliasnikoff and I returned to Big End Chasm and Koliasnikoff re-rigged the first and second pitches. We needed the ladder for a drop in the middle of Hecate's Crack, a climb I had done the previous day but would have been unhappy to repeat. I also decided to re-rig the rope above Hecate's Crack, making the main entry point a hole below the squeeze that Ward had enterprisingly dug the previous day in his efforts to help Koliasnikoff out of the squeeze. This resulted in a rather unorthodox changeover to the main rope, which worked well for all except one member of the expedition, who nearly suffered a heart attack while trying to abseil down a 50 m pitch off a 6 m length of rope.

We descended to the bottom and surveyed the chamber, naming this part the "Upper World". We could not survey the main pitch as the tape was not long enough. After rigging the ladder we went to the base of the chamber and Koliasnikoff began to rig the next pitch. At this point we were again joined by Ward, who seemed to have developed a taste for solo caving. Just as he arrived Koliasnikoff's


BIG END CHASM (Z3)
Chimanimani
PLAN VIEWS OF MAIN CHAMBERS
N
0
5
10
15m
HALL OF THE LOST PROVITA
BOULDER FLOOR
TOO TIGHT CRACK LINKING TO SHAFT BELOW
-5
POOL
HOLE TO SHAFT BELOW
SHAFT
LOOSE RUBBLE SLOPE
LEDGE USEFUL WHEN RIGGING
HECATE'S CRACK (UPPER WORLD)
-2
5M CLIMB LEADING TO PITCHES
LOOSE BOULDERS
30°
BOTTOM OF 'AK47' PITCH
BOULDER SLOPE
UNSTABLE CLIMB
4M PIT BELOW BOULDER
LADDER
-7
ALTERNATIVE ROUTE
BOULDER SLOPE
45°
30°
-17
PIT TO LOWER WORLD
HECATE'S CRACK (LOWER WORLD)
TIGHT HOLE
-2
SAND/PEBBLES
?
-5
CLIMB UP INTO BOULDER CHOKE
SAND/PEBBLE FLOOR
BOTTOM OF PITCH
BOULDERS
BOTTOM -150M DRAFT THRU' SMALL BOULDERS



Big End Chasm (Z3)



Dave Ward on the bottom of the "Upper World" in "Hecate's Crack" in Big End Chasm. (T.F. Truluck)

carbide gave out, followed shortly by a flat battery on his reserve lamp. While he was restoring his light I finished the rig and descended. Following a re-belay at the top, the pitch was a free-hang of about 20 m, leading down to a chamber of about 8 by 10 m, named the "Lower World". There was a stream going down a very narrow crack at the one end behind the pitch, and at the far end I followed the chamber down to a very choked boulder choke with a draught in it. We spent a while moving rocks, but we did not seem to be getting anywhere, and eventually gave up. That, as far as we were able to determine, was the bottom of the cave, at an official depth of -150 m. However, there is definitely a draught down there. On a photographic trip, Truluck, Ward and Holland managed to measure the length of the main pitch in Hecate's Crack, with the aid of a 50 m tape; it came to 47 m to the top of a 3 m high rock. The pitch was thus named "AK47". The cave was de-rigged by J-P Le Roux and Stuart Page. Page investigated a hole at the top end of the Hecate's Crack Chamber that Koliasnikoff had found during the survey. It went down about 20 m, and then narrowed to a crack. Le Roux estimated the dimensions which are included on the survey as BCRA grade 1.

The Survey and Re-Bolting of Bounding Pot (Z1)

T.F. Truluck

Bounding Pot was visited on all three previous expeditions; SASA (Tvl) and Stuart Page (Outward Bound Zimbabwe) hand-bolted down to Tar Chamber and reported that the cave was at least another 100 m deeper, claiming a total depth of over -250 m (Le Roux *et al* 1993). The Zimbabwe Mountain Club, lead by the late Thorley Sweetman and including Stuart Page, Jeff and Ellen Broome, who were also involved in the 1993 Expedition, bottomed the cave in 1991. They surveyed it using rope lengths and estimated a depth of -191 m (Sweetman 1991). The ill-fated 1992 Expedition by members of SASA (Cape) bottomed the cave before being arrested for illegal mining (Le Roux *et al* 1993). It was the aim of this expedition to re-rig the cave using stainless steel bolts, to accurately re-survey using compass, clinometer and tape-measure and to conduct a dye-tracing test to determine whether the cave is linked with the Resurgence Cave about 1½ km away. The results are documented in excerpts from the expedition diary:

Friday 13 August

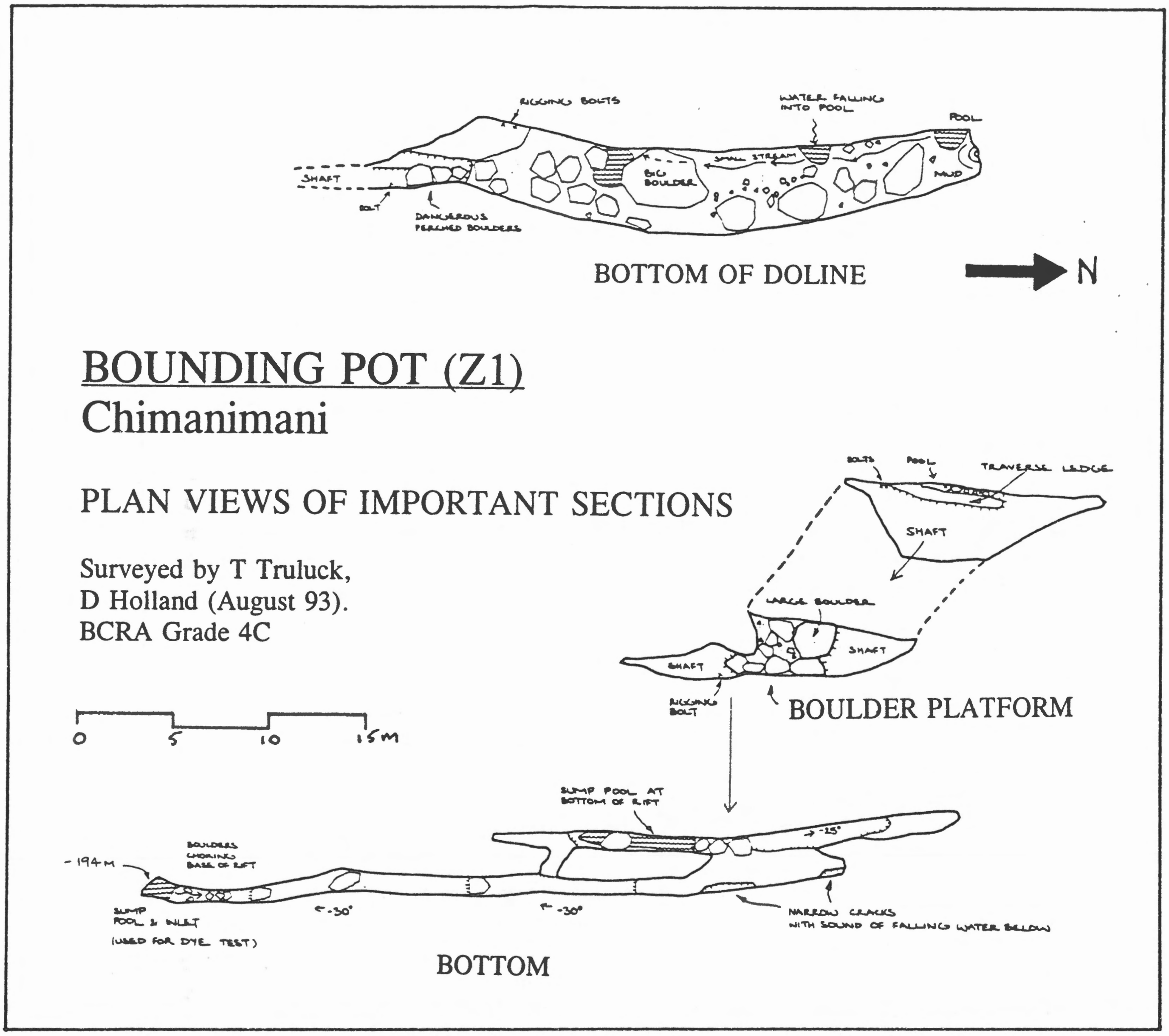
More drizzle during the early morning. Cleared mid-morning and was quite warm until about 14h00. Biting, icy wind prevailed until mist and strong winds blew in after dark. General lethargy, prevailed among the cavers during the morning. After breakfast, most returned to their tents to read and sleep until the mist lifted.

By late morning, the sky cleared and Koliasnikoff and Harley prepared themselves to go to Bounding Pot. Three visitors appeared and helped the caving team carry some of the gear to Bounding Pot. After a short time, Harley and Koliasnikoff returned to the camp site to collect some rigging items. They returned after caving at about 20h30. We had to close the tent flap as it got very cold and misty. There are only seven in camp (the others are at the Resurgence Cave) and it is very quiet.

Saturday 14 August

The weather was initially very cold and misty with drizzle. However, it cleared at about 11h00. It became very cold again after dark. Koliasnikoff brought me a mug of coffee in bed - very good of him. Koliasnikoff and Harley wanted to go caving at 10h30, but they eventually only departed at about 12h30. Their plan was to descend into Bounding Pot and finish rigging to the bottom. They would then deposit 500 ml of dye (Rhodamine B) in the stream. Holland and I were follow them a little later and begin the survey work.

Holland and I arrived at the entrance to Bounding Pot at 13h45. I abseiled to the top of the 34 m pitch leading to the bottom of the doline. However, Harley was still messing about with



a deviation just below me. I waited for him for over 30 minutes. After Holland and I had descended, we found that Koliasnikoff and Harley were not likely to have finished the rigging that day. We surveyed the bottom of the doline and prussiked out. While Holland was prussiking, he dropped the tape measure from about 20 m, which just missed me.

We returned to the camp site in the mid-afternoon and met some ZMC members, including Andy Heelas, Honorary Vice-Chairman and head of mountain rescue. They were impressed with the camp site and the women in the party appreciated the civilised toilets. Koliasnikoff and Harley returned at about 19h30. Apparently the batteries for the drill were flat, and they still had to rig the last 40 m pitch to the bottom. It was a good thing that Holland and I did not stay on to survey the cave. They will return again tomorrow, finish off rigging and conduct the dye trace.

Later that evening, we were all huddled in the big tent. While Aucamp is away at the Resurgence, we have been raiding the Willard's crisps and Cadbury's Hot Chocolate, as we needed to boost our morale because the weather was so foul.

Sunday 15 August

Weather in the morning was very depressing - mist and slight drizzle becoming quite heavy at times. The sun never showed itself the whole day. Koliasnikoff and Harley went to finish rigging Bounding Pot. Koliasnikoff wanted to return at 16h30 so that he could walk down to the Bundi Hut for the night before continuing to Base Camp to get some more supplies. However, they eventually returned at 19h30. Apparently Koliasnikoff had an urgent call of nature while on the rope and it took him over an hour to find a suitable place on a boulder near the last pitch. They also dropped the hammer, drill bits and a drill battery. The battery fell about 30 m and, although it didn't work any more, it looked remarkably undamaged.

Bounding Pot is now fully rigged, except for one bolt on the last pitch. They also placed the 500 ml of Rhodamine-B dye in the pool at the bottom. Stuart Page from Swaziland joined us today. Supper was the usual TVP, except that Le Roux cooked a packet of mushrooms that Page had donated to the common cause. I also made rice pudding which went down well.

Monday 16 August

It was cold, misty and windy in the early morning. After midday it cleared and was quite sunny and warm. Evening was clear with a bit of wind. Holland and I went off to survey Bounding Pot. Harley joined and passed us to complete the bolting of the last pitch. We surveyed down. Once past the bottom of the doline, the cave is a narrow, but long crack which slopes down at an angle of 70° to the South. The crack narrows to less than a metre wide in places.

The worst place is the pitch leading off from the doline. When prussiking out you have to pull yourself onto the ledge above and walk along it. If you prussik below the ledge you end up stuck in the crack as it narrows even further. Usually the cave is 2-3 m wide. There are several traverses while on the rope where you have to pull yourself across to the next belay. You are also on the rope all the way down. As we were descending we met Harley coming up. One of the two drill batteries had stopped working, so he couldn't finish bolting. Harley passed me while I sat unattached to the rope, perched on some wedged boulders.

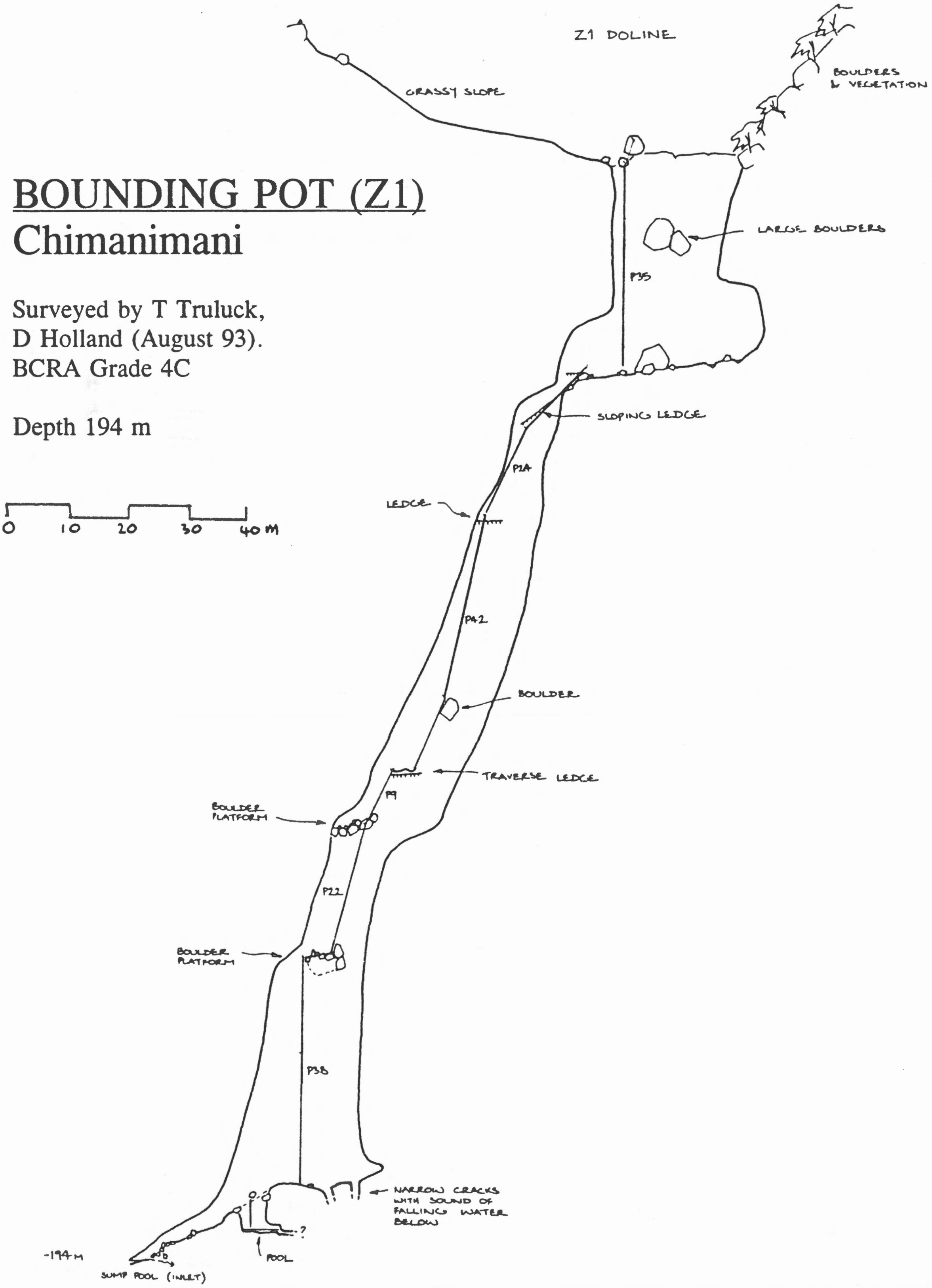
Eventually we reached the bottom. There is a continuous noise of running water, which sounds like a crowd applauding you for arriving at the bottom. The pools of water are reached via a steeply sloping passage to the south. We surveyed down to the main pool of water which was still red from the previous day's dye-tracing. Holland freaked out a bit, but cheered up when he had a Kejo "Spaghetti with Meat" meal and a Mars Bar.

Prussiking out was a long, steady haul, with no major problems except for a few tricky re-belays. Holland, who was ahead of me, dropped a rope protector from below the traverse about half way up. This seems to be the cave for dropping things. The cave slants up to the right and, on the way up, the rope trails to the left and fouls the nice neat SRT manoeuvres learnt in easy caves and in the fire-tower before the expedition. We returned to the camp site just before nightfall. We washed up and tucked into the TVP and pasta, with half a salami shared between us.

BOUNDING POT (Z1)
Chimanimani

Surveyed by T Truluck,
D Holland (August 93).
BCRA Grade 4C

Depth 194 m



I entered the survey data into the IBM computer and ran the COMPASS programme, which indicted that the cave was -205 m deep. I rechecked it, found a mistake, recalculated. The cave was 194.63 m deep, which is pretty close to the ZMC survey of 191 m !

Various things have been dropped in Bounding Pot so far, all except the rope protector having been retrieved:

Koliasnikoff:	*Hammer, drill battery, glove*
Harley:	*Spanner*
Holland:	*50 m survey tape, rope protector*

Saturday 21 August

The weather was warm, with no frost and hot in the afternoon. There was no wind. Le Roux and Ward were to push the stream passage at the bottom of Bounding Pot and de-rig the cave. They eventually left after Le Roux had to entertain the Head of Chimanimani National Park, Mr Wellington Mafuka. The highlight of the guided tour was showing him Lisa sitting on the field toilet. They got to the bottom of the cave and found that the stream had risen compared to the last time Le Roux had been there in 1992. There was no air space, so no pushing was done. They did not find any of the amphipods that Le Roux had 'noticed' last time either.

Le Roux was amazed at how much smaller and less dangerous Bounding Pot now seemed. As they were going to push the stream, they were wearing wetsuits under their oversuits. Le Roux's suit was too tight, combining with his harness to give him a case of testicle squeeze as he prussiked out. They de-rigged the cave and returned to camp at 22h30.

The Resurgence Cave

D.P. Ward

On Wednesday 11 August, Jeff and Ellen Broome, Jonathan Timberlake (ZMC) and I left the camp site at Turret Towers to walk down to the Resurgence Cave overlooking Bundi Valley, some 500 m lower down and 1·5 km away. Jeff Broome was in the lead as we made our way down on a clear and warm day. Before we left there was some joking as to the size of my pack, as my white butcher's boots, overall, helmet, tent, tent poles and large sleeping bag were all tied to the outside! Only the 'Backpacker' label was visible. Jeff Broome led us down some extremely steep grassy slopes, which seemed almost vertical, after scouting around for the correct route. Before descending, we had lunch at a balancing rock where the view of the resurgence gorge and valley below was tremen-

dous. Before reaching our destination, we had to negotiate a rift above the resurgence with a ladder and a handline.

We pitched our tents next to the path to Terry's Cave and overhang, near the resurgent stream, and had a wash in the stream. The next day, Thursday 12 August, we all went to explore the resurgence, which was about 20 minutes walk up a steep slope. The entrance is just below a fairly large doline, about the size of Z7. The gorge at this point is filled with large boulders, among which the small boulder choked entrance leads into a large cavern. The cave was surveyed from an ear shaped rock outside, through the thick bush, down the entrance slope and then upstream from the large chamber. The passage was found to extend for about 140 m eastwards, as a fairly constant 10 m high by 3 m wide crack with boulders in the roof. The way is sometimes blocked by boulders which have to be climbed over or under.

Jeff and Ellen Broome managed to get through a really tight squeeze, which I tried, but wisely decided to decline. They then completed another 40 m of survey to a small cairn that they had built. Jeff Broome said that the cave went further, but was tighter, wetter and there was a short vertical pitch to negotiate. Timberlake and I explored further downstream, after which we had lunch outside in the sun. Robert Battersby and Jane Dobney (ZMC), who had walked down from Turret Towers, were spotted above the crack and Jeff went to assist them down the ladder. They were amazed at the steepness of the descent.

The following day, Friday 13 August, Timberlake departed. Battersby, Dobney and I surveyed the downstream part of the resurgence to the daylight in the large chamber. Later on Dobney, who had caved in the UK and was used to tight, wet caves, squeezed through the tight bit fairly easily and continued to the cairn. That evening we walked to Terry's Cave, to find Pete Aucamp and Lisa Casalvolone, who had arrived at the camp. On Saturday 14 August we all went to the resurgence. Casalvolone had difficulty in moving rapidly in her Integral Safety oversuit, but Aucamp, Casalvolone and Dobney got through the squeeze, although Aucamp damaged one of his ribs. Aucamp reported that he had gone up the vertical, wet section and had encountered a large chamber that ended in a tight choke. He explored above the squeeze for another way through, with no luck.

We all retreated to the campsite and made contact with J-P Le Roux, who said that the dye would be dumped in Bounding Pot the next day. We were to place cotton wool dye detectors in the stream in the Resurgence Cave. On Sunday 15 August, while the ZMC group left for home, Aucamp, Casalvolone and I went to explore the doline near the entrance to Resurgence Cave. We lowered a ladder into the doline, but it did not even reach half way down the 5 m by 3 m by 20 m deep shaft. Looking into the shaft, it didn't seem to go at all, so we packed up and left the campsite at lunchtime, to make our way back to Turret Towers via the Bundi Hut.

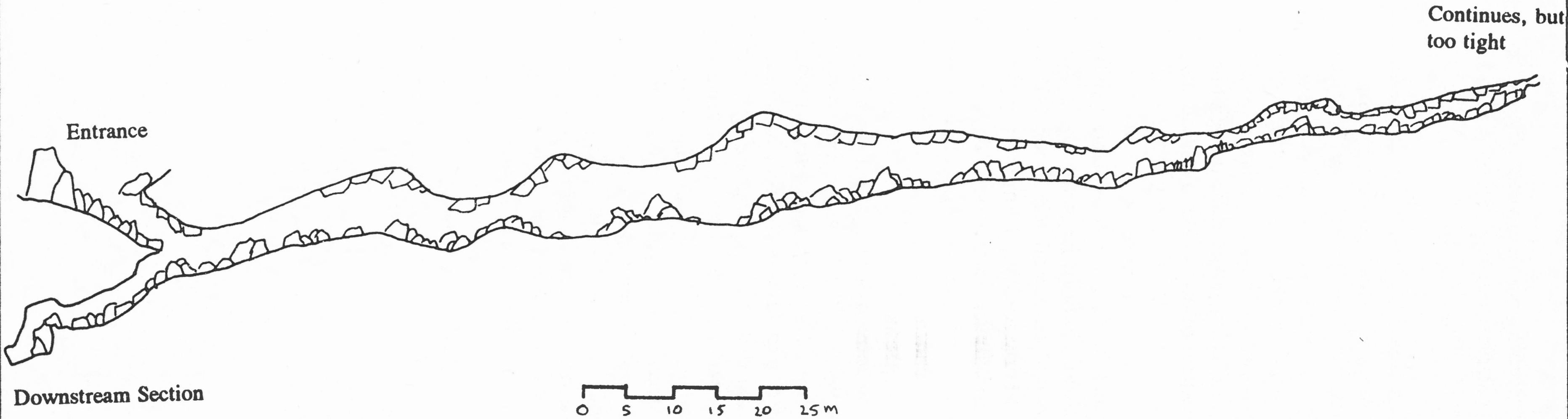
On Thursday 19 August Darryl Holland and I returned to the Resurgence Cave to inspect the cotton wool placed in the downstream section of the cave. The cotton wool had no traces of dye, so we removed it and took a few photos of the cave. The walk to the cave via Lap of the Gods took 4½ hours and the return up the steep slope between peaks 71A and Turret Towers took 2½ hours.

RESURGENCE CAVE
Chimanimani

SECTION

Surveyed by P Aucamp, L Casalvolone,
J Broome, E Broome, D Ward, R Battersby,
J Dobney (August 93).
BCRA Grade 4C

Length 217 m



Zee-in-Ze-Middle (Z7)

T.F. Truluck

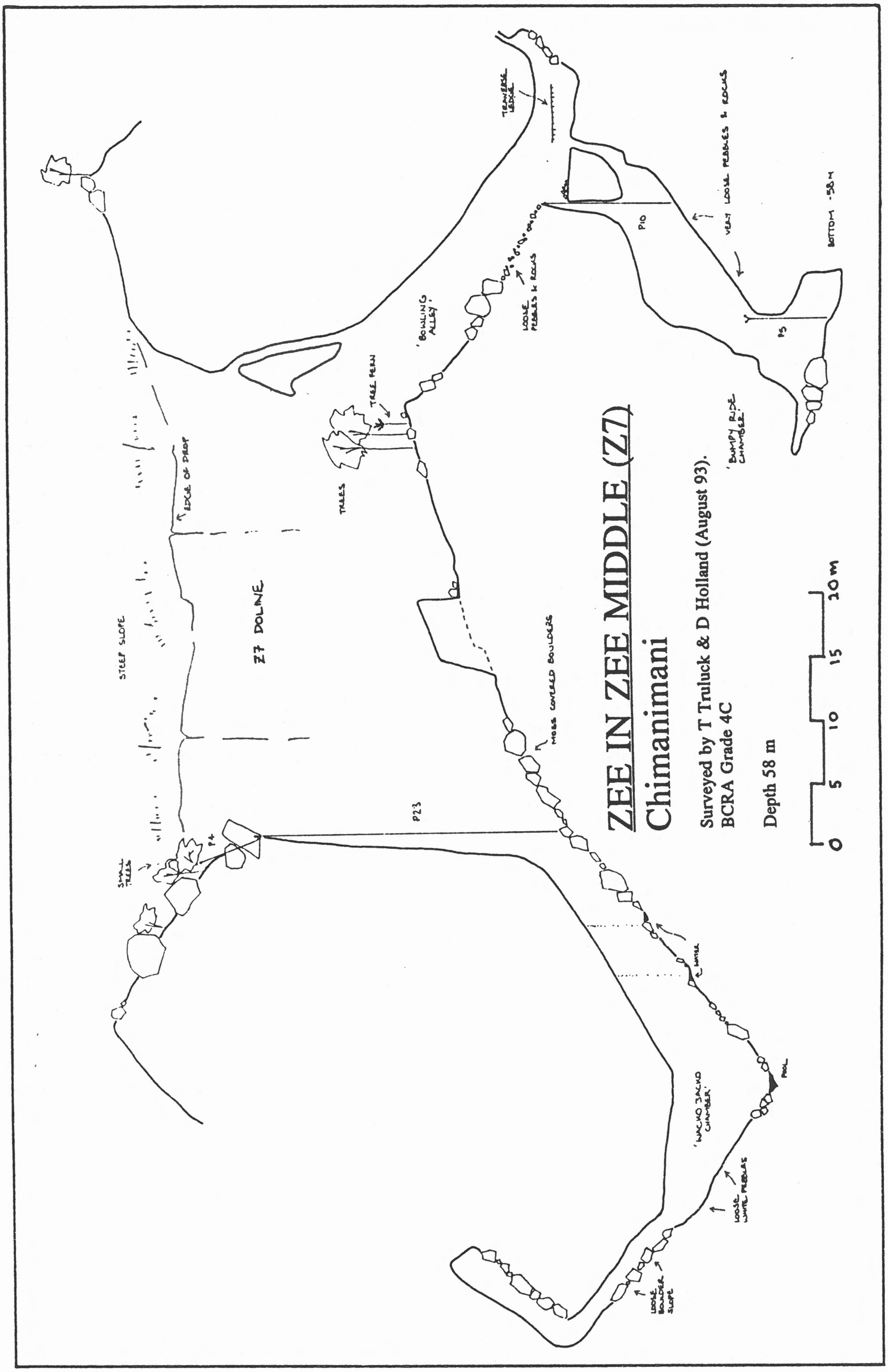
I first saw the Z7 Doline on an orientation walkabout conducted by J-P Le Roux on our first day at Turret Towers. It is probably the most sheer and compact doline in the area, being about 45 m long, 15 m wide and 25 m deep. It is situated on a fault line between the Z3 and Z1 Dolines, hence its name 'Zee-in-Ze-Middle'. It had been noted on previous expeditions, but had not yet been investigated (Le Roux *et al* 1993).

On 17 August, Stuart Page, Pete Aucamp and I decided to investigate the Z7 Doline. After having a walk around the edge, it was decided to enter the doline from the south (Z1) side. A short scramble through some boulders and scrub, brought us to a large tree which protrudes over a 27 m drop. The rope was belayed from this tree and we abseiled at a 45° angle to the right to a large rock which overhangs the doline. Once a re-belay in the rock is passed, there is a very nice 23 m free-hanging pitch to the bottom of the doline.

Once off the rope, we doubled back under the south end and followed a steep slope with many loose boulders. As Pete was caving with one glove on to protect his cut thumb, we called this 'Wacko Jacko Chamber', after Michael Jackson, who often appears on stage with one glove. The slope bottoms out and begins to slope steeply up again, narrowing upwards and becoming fairly treacherous due to the number of loose boulders waiting to be dislodged. The passage terminates in a chamber which almost reaches the surface. We then explored the bottom of the doline to the north end. We climbed down into another steeply sloping, but high roofed chamber, with a 3·5 m drop at the end. There were many loose rocks and stones which rolled down while we were climbing down the pitch, prompting the name "Bowling Alley Chamber". Once past the 3·5 m pitch there is a small chamber which terminates at the north end in some very loose material. Directly under the 3·5 m pitch, there is another SRT pitch heading down for about 10 m. This leads into a very unstable passage which slopes back under the doline towards the south. The north end of the passage slopes up to join the small chamber where the 3·5 m pitch bottoms.

Following the rope southwards down the sloping passage there is a short 5 m pitch. The descent on the rope was not very smooth and we called it "Bumpy Ride Chamber". There was no way on from this chamber. Despite the absence of light, there were some interesting algae on the wall in this part of the cave, which were flowering with red blooms.

The doline and cave were a bit of a disappointment as they did not extend to any great depth. However, this is a good training cave for newcomers to the area, and the 23 m abseil is good fun. The approach to the doline edge may be fairly treacherous, however, as found by Pete Aucamp and J-P Le Roux, who were returning from a caving trip in Mawenge Mwena when they became disorientated in the dark and the heavy mist. Responding to their whistles and shouts for help, we found them attempting to scramble down a slope which would have dropped them over 40 m into the Z7 Doline!



Zee-in-Ze-Middle (Z7)

The Mozambique Dolines

A. Koliasnikoff

On 9 August David Harley and I set off in search of new dolines. During preparation for the expedition, we had identified a promising area in Mozambique on 1:20 000 aerial photographs and on the Chimanimani 1:50 000 topographical map, which indicated a group of streams in close proximity that appeared to sink into closed depressions. The 3D stereoscopic aerial survey photos confirmed that the area contained at least two large depressions, subsequently located during our surface reconnaissance. The group of rifts and dolines in this area has been named the Mozambique Dolines.

Our reconnaissance began with the discovery of M1 Doline, shortly after crossing Eastern Ridge. From the M1 Doline we descended into the large gulley below Eastern Ridge, following a stream for about 500 m before crossing to the opposite bank to the area formed by the junction of several fault lines. We found a small stream sink almost immediately,. We followed the course of the stream along the surface and examined several holes down to the stream by throwing rocks down them. The deepest of these appeared to be about 5 m.

The course of the stream continued beneath several large rocks before reappearing under an overhanging ledge. We explored under the rocks for a short distance, finding several short sections of cave passage. Also in this area were a number of attractive pools and a small waterfall, as well as a large inclined area of rock which closely resembled limestone pavement karst in appearance.

Labyrinth 2

From there we headed for more interesting territory. Ahead of us lay a large plateau bounded on its north side by a small peak and on its western and southern edges by steep cliffs. We gained access to the plateau by a grassy gulley, to find it highly weathered, resembling pavement karst. The plateau is inclined, with its lower edge to the north and its higher edge to the south. Water draining from the plateau should run towards the north but we found that it appears to drain in the opposite direction through a complex network of deep, narrow rifts. These occur about every 10 m, turning the area into a complex maze that was difficult to traverse.

Many of the rifts appeared to be up to 15 m deep in places. We climbed down into one to a depth of about 8 m and threw rocks down about the same distance again. The rocks landed in water, and we noted that there was rift development below the surface that did not always correspond with surface openings. The area seems to consist of an extensive system of open rifts and quasi-cave passages.

The rifts were 1 m to 3 m wide at the surface, and the one that we investigated was inclined at an angle of 30 degrees to the vertical. The main rifts predominantly run in a north-south direction, but are crossed at frequent intervals by other rifts running perpendicular to the main rifts, breaking the plateau into numerous rectangular islands of rock.

The similarity of the plateau to the Labyrinth in the Bundi Plain led to it being named Labyrinth 2. Only a small area on its western edge was investigated due to the difficulty of traversing the area. We were later able to view the cliffs on this edge from below and could see a distinct bedding plane about 15 m below the top edge of the cliffs. We were impressed by the potential of the area. It is possible that the plateau could be underlain by an extensive system of cave passages, and resurgences may occur along the southern edge of the plateau.

The M2 Doline

We were unable to leave the plateau on the southern side and so were forced to retrace our path to where we had entered the area. As we were about to leave the plateau, we noticed a depression at the foot of the small peak on the northern edge. This depression lies on a fault line and is one of the two depressions identified on the aerial photo.

The depression has developed at the junction with a smaller cross fault. A stream crosses the depression from north to south, passing under large boulders in the centre of the depression. The outlet of the stream was found in a deep, narrow rift on the south side, so the depression is not closed. The exit rift was only briefly examined, but may develop cave passage at its southerly end, to connect into the adjacent Labyrinth 2 system of rifts.

The M3 Gorge

We followed the stream in the gorge for a short distance before it disappeared from view beneath boulders. A short distance further it resurfaced again, and we were surprised to find that its course then turned east through an angle of 90 degrees to follow a fault line, instead of continuing south. It seems that this is the result of river capture. The stream passed through broken terrain, dropping into a gorge, and we followed its course along the northern bank of the gorge, which deepened towards the east. We noticed, to our increasing excitement, that the gorge was not a valley, and appeared to terminate in a large, closed depression. The water catchment area for the stream in the gorge is several times larger than that of the Frontier Shafts area, suggesting that a large volume of water sinks in the depression during periods of heavy rainfall.

The M3 Doline

This large doline at the end of the gorge is the other major depression that we had previously identified from the aerial photo. It took a long time for us to traverse around the steep slopes of the doline, but we eventually reached a point where we could view the whole doline. The stream enters the doline from the base of the M3 Gorge, which is estimated to be about 40 m deep. The water was not visible from our viewpoint and possibly runs beneath the large boulders lining the bottom of the gorge. It is also possible that the stream sinks in the floor of the gorge before reaching the doline. Another stream cascades into the doline above where the gorge is entered. This forms a spectacular waterfall with a clear drop from the vertical walls.

We determined three possible access routes into the bottom of the doline:

i) To climb down the eastern slopes, making a path through the thick vegetation, similar to that in the Z3, Z4 and M1 Dolines;
ii) To abseil directly into the doline from the cliffs adjacent to the waterfall mentioned above;
iii) To follow the M3 Stream through the gorge to its entry point at the base of the doline.

We continued to circumnavigate the M3 Doline to a point on the southern rim, where we found a smaller cross fault which links across a spur of rocky terrain to the deep gulley, following another fault line. This parallel gulley was an impressive sight with steep slopes and a deep gorge at its eastern end. We speculated that the M3 Stream may resurge somewhere below in the more southerly gorge. Alternately, there may be a resurgence further to the east.

Conclusions

Our long walk home offered no further discoveries, but this did little to alter our impression of the great caving potential of the Mozambique Dolines. Unfortunately, due to limited time and commitment to surveying the Z Dolines, we were unable to follow up these discoveries, and the Mozambique Dolines will have to await exploration by a future expedition.

Exploration of the M1 Rift:
The Discovery of Mozpot

A. Koliasnikoff

The M1 Doline was discovered just within the Mozambique border by Dave Harley and I during a reconnaissance walk on 9 August. After crossing a ridge to the south-west of the camp site, we were surprised to find another large doline only a short distance from the Z1 Doline. A study of the aerial photo shows that the new doline belongs to the Frontier Shafts group of dolines. The Z11 Doline lies at the intersection of two fault lines that are clearly visible on the aerial photo. One fault line appears to be a continuation of the fault running through Z1, Z7 and Z3 Dolines in a north-south direction. Where this fault joins the M1 Doline, it forms a rift up to 40 m deep. A second fault line running east-west passes from M1 doline, over the Mawenge Ridge between Turret Towers and Point 71A, and down to the Bundi Valley.

We approached the M1 Doline by following the well defined rift which runs for about 200 m into the doline. We then made a circuit of the doline to confirm that it was closed. Several potential access points were noted but, because this doline was not our primary destination, we decided to leave further exploration for the following day. On 10 August, Le Roux, Harley and I returned to explore and survey the doline. While Harley and Le Roux started the survey, I began exploring the western end of Z11 Rift. Following the rift for a short distance, I climbed under boulders and through thick vegetation until I reached a point where the rift suddenly deepened. The vegetation was so thick at this point that it was difficult to see where I was going. I slipped and fell between some boulders into a hole that opened over a drop of several metres. Luckily the vegetation caught my fall and I was able to chimney out.

On the northern side of the rift I found a small depression with a cave entrance at its base. This small cave proved to be a useful link back into the deeper section of M1 Rift. Using my SRT gear to make a handline of about 4 m in length, I was able to climb down to the floor. I followed the rift until it roofed over and became a cave passage in darkness. At several points light filtered through the boulders in the roof, now high above. I reached a point where the rift narrowed to a tight crack, but was stopped from further exploration by the failure of my electric lamp. I was not carrying a spare battery so I tried my carbide lamp, without any success. I was therefore faced with the problem of tracing the fault in my carbide lamp in almost complete darkness.

After first cleaning the jet and checking the generator to see if the water dropper was clogged, I noticed there was a strong smell of carbide, not coming from the jet, but from a hole in the pipe close to the top of the generator. I patched this partially successfully by removing the Hilti stickers from my helmet and applying them to the pipe. I then retraced my steps using the improvised handline and met the other two who were still busy surveying. My experiences in M1 Rift highlight the dangers of caving alone.

Harley and I returned on 21 August to survey this section of the rift. Harley squeezed through at the previous end-point. Here he encountered a deep pool in a narrow crack. We decided we should first explore the lower sections of the rift before pushing beyond the pool. We attempted to find a route down the east side of the doline, but the grassy slopes were thick with vegetation and a panga was needed to cut a path. Our route took us under several large boulders, guided by the sound of running water coming from deep below. I rigged a rope so that I could reach the deep, mossy hole at the centre of the doline. This route seemed to require proper bolting so I moved the rope to another drop that passed down through the boul-

ders at the eastern end, the "Alternative Route Down". Le Roux abseiled into a chamber containing several small pools, and was able to squeeze through to a second chamber which was roofed by a large suspended boulder, the "Amazing Levitating Boulder" (ALB). The boulder appeared to be resting on a single small chock boulder and looked just like a trap-door, so Le Roux named the chamber "Trapdoor Chamber". Harley and Le Roux continued the survey to a depth of -45 m. A promising hole in the floor, with a pool at the bottom, seemed to be the way on.

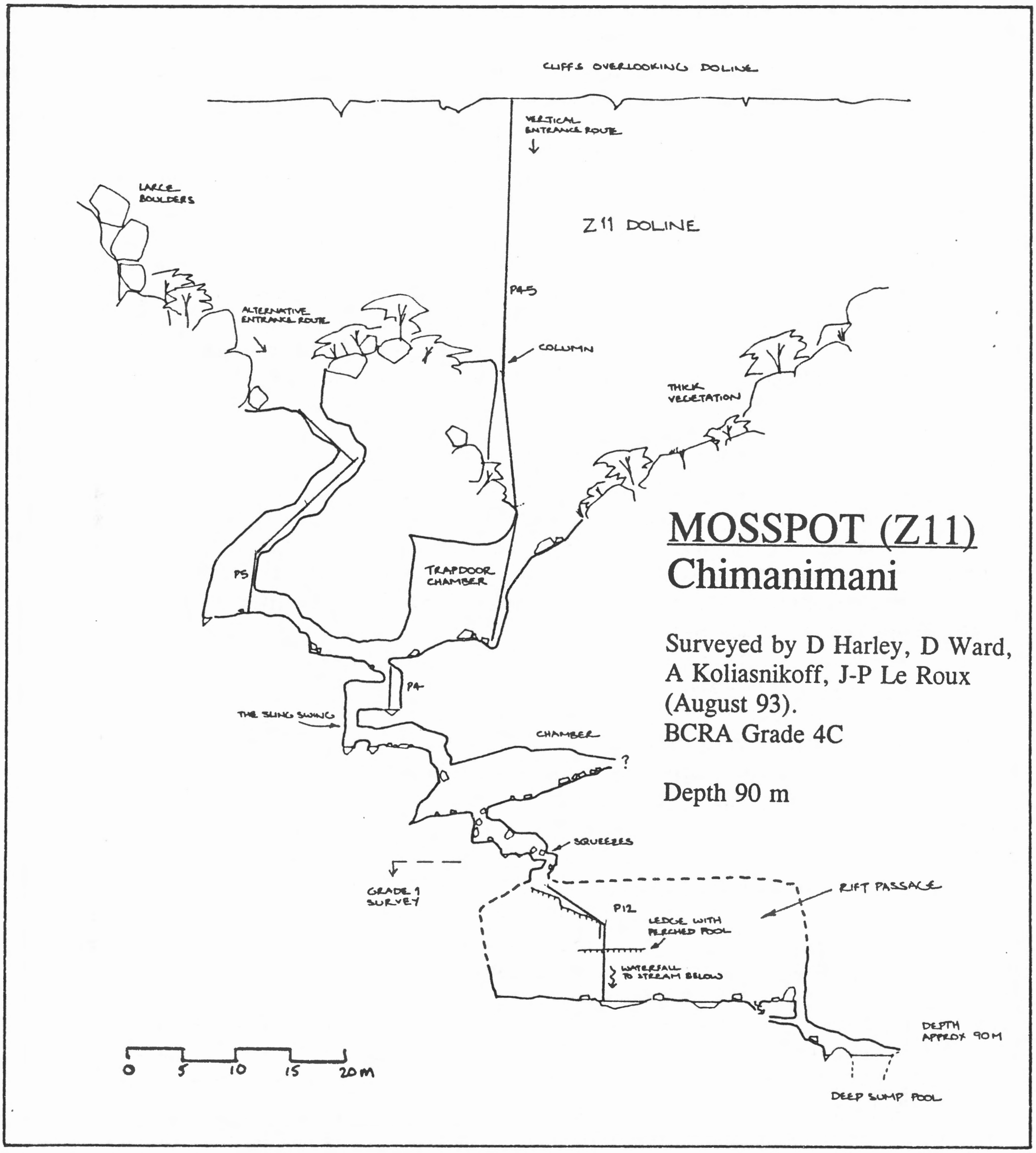
Due to work in progress in the other dolines, we did not return to M1 until 21 August. Harley and I set out, fully equipped with Hilti drill, ropes and rigging gear, hoping to find a new shaft. We surveyed part of the rift before proceeding to our main objective of investigating the deep pool encountered a few days before. Harley had previously identified an overhanging cliff that would provide a direct hang into the centre of the doline. This would enable us to abseil quickly into the centre of the doline. The top belay was rigged with the aid of a long wire hawser and several rope protectors. Harley rigged a re-belay on a tall column of rock about 25 m down. A second re-belay and a deviation dropped us directly into "Trapdoor Chamber", providing us with a much more elegant route to our previous limit.

I was wearing a wetsuit in preparation for a swim in the pool. Reluctant to get wet, I first tried climbing up the boulder pile in the rift, hoping to find an easier or dryer by-pass. Soon a promising hole was found, but it was choked at floor level leaving only small gaps between the boulders. Rocks dropped into these bounced downwards for a short distance. Getting out of this hole proved to be more difficult than getting in; I had to prusik up Harley's foot-loops! No alternative route was located so we returned to "Trapdoor Chamber". I chimneyed down to the pool and was pleasantly surprised to find no swimming was required. It was possible to simply step round the pool into a chamber hidden from view just to the left, where another short chimney led to a lower chamber. The amount of water in this cave seemed to exceed that in any of the other caves that had been so far explored. Most of the boulders were well rounded and washed clean to an almost white colour.

Some more climbing down through boulders led to an unstable looking boulder choke. The water was draining through this choke into a cavity below. We could hear the echoing sound of falling water beyond the boulders. We managed to clear a small hole in the choke through which we could squeeze. The hole was occupied by a sleeping bat which we carefully squeezed past, and a short climb led to the cavity below. A spur of rock gave us a platform from which we could stare down into what looked like deep pools of water some 10-15 m below. The development of the cave was now becoming more clear to us. The large rift that terminates in the M1 Doline continues below the surface, but is choked with boulders forming a sequence of chambers. The rift narrows to a width of about 2 m at around -70 m, and widens agin further down. We were optimistic that we had broken through into another deep shaft similar to those already discovered in Z1, Z2, Z3 and Z4.

During the previous week, some of us had become pessimistic as to whether the Frontier Shafts area would produce any further deep caves beyond the four already found. We had hoped to find shafts in Z5, Z6, Z7 and Z8, but these had proved disappointing. However, on the same day as we discovered Mozpot, Aucamp, Le Roux and Page had begun exploring a new hole found in Z9 Rift, which was ultimately to become Mawenge Mwena. That evening at camp optimism ran high as the two teams shared news of the day's discoveries. The Frontier Shafts area once again seemed to hold the potential for new surprises.

In high spirits we set out the next day for Mosspot armed with a fistful of bolts and hangers and another 100 m of rope. We rigged an elegant little 4 m pitch down to the first pool, probably the most pleasant SRT pitch I have ever descended ! I promptly abseiled straight into the pool below. The pool was so clear, it was difficult to see the pool surface. Unfortunately, the Hilti drill was hanging from a cowstail between my legs, and we had to shake the water from the drill by swinging it around, giving rise to a new expression to describe the size of a chamber: "Enough room to swing a drill". We also changed the battery, which would only run on slow speed once it became wet. At the previous limit of exploration, I placed two bolts whilst sitting under a small waterfall. These were



MOSSPOT (Z11)
Chimanimani

Surveyed by D Harley, D Ward, A Koliasnikoff, J-P Le Roux (August 93).
BCRA Grade 4C

Depth 90 m

for a Y-hang so that we could descend the third pitch to the deep pools. While drilling a hole for a re-belay, the second battery also starting giving problems. This was the ultimate frustration. We had reached our previous limit but could progress no further. More swinging the drill and swapping batteries got us nowhere, but time was running out (we had only two days left) and I was determined to find out what lay below. We improvised an arrangement of rope and ladder that enabled me to climb down to the surface of the deep pool. I was not wearing my wetsuit, so we decided not to try pushing any further. We had surveyed down to the Y-hang, so the day was not completely wasted. Mozpot, however, still remained as much a mystery as it had the day before.

We prussiked out of the doline in the rain and mist, and arrived back at camp wet and miserable. That evening we worked on the drill and batteries

without success. The other drill and batteries were needed for the big push in Mawenge Mwena, which was now still going at about -240 m. We would therefore have to hand bolt to do any further pushing in Mozpot. The following morning was wet and horrible. Harley decided he had had enough and opted for a day off - wise man!. The next day Harley and I were scheduled to de-rig Mawenge Mwena on the last day of the expedition. After much persuasion, Dave Ward eventually 'volunteered' to join me for a last push and de-rig in Mozpot.

Abseiling down the entrance pitch in the mist was a peculiar experience. Visibility was reduced to less than 20 m and the bottom of the doline was completely obscured. Even our lights could not penetrate the thick vapour. The cave was at least five times wetter than on the previous day, and everywhere we could hear the sound of fast-running water. The "Sling Swing" was now made much more interesting by the addition of a jet of water which sprang horizontally from the adjacent wall. The top of thethird pitch was also now below a substantial waterfall, so this was quickly passed. It took me over 20 minutes to hand place the bolt for the re-belay. I inserted a hanger and then pulled out both the anchor and hanger by hand. The rock was clearly rotten. We were in the same frustrating position as on the day before.

Trying hard to keep my cool, I decided to try abseiling over the end of the rock spur which I was perched on, although this route held the twin dangers of slipping into tight slots on both sides of the spur. The short pitch led to a section of rock that acted as a dam to the deep pool that I had reached the previous day. The next section of the pitch to the lower pool necessitated the unusual practice of abseiling upside down with one's feet on the ceiling to avoid slipping into one of the tight slots. We now found that this was not the anticipated shaft. Instead we had descended into a decent sized stream passage following the line of the rift. The east end closed down after less than 10 m. The other direction looked more promising.

The stream passage had several shallow pools along its length, but soon terminated at a point where the stream sank between boulders in the floor. We found a place where it was possible to chimney down, but this route soon choked. Stones dropped through cracks fell into a pool below. I moved a few boulders at my feet and, after a short while, the remaining boulders collapsed below me, clearing the choke. A short clescent led to a sump pool with frothy scum on its surface and on the walls adjacent to the pool, indicating that the water level must fluctuate. The pool was about 5 m long and terminated in a narrow crack. I lowered myself into the pool and was able to see walls disappearing down into the darkness below . It is possible that the water level drops during dry periods and may provide access to dry passage below this point, which was at about -90 m. A lot of water was running into the cave, and the lower parts may have been flooded.

Getting up the third pitch proved quite difficult. Ward pulled the rope out of the slot whilst I prussiked up. I then turned myself into a human chockstone whilst Ward prussiked below me. The cave was definitely testing our resourcefulness, but 'Where there's a will there's a way'. We left the cave, carrying about 35 kg of rigging equipment that had been used in the cave during the previous two days. We de-rigged as far as "Trapdoor Chamber", leaving the first pitch for Le Roux to clear the next day.

The cave below the Y-hang still needs surveying and a return visit would be worthwhile to check the water level in the sump. The pool could be dived if no alternative route can be found. The stream in Mozpot heads in the direction of Bounding Pot, and there is is no apparent surface sink for the stream at the bottom of Bounding Pot, other than M1 Doline about 400 m away. A dye-test between the two caves would certainly be worthwhile. There is also a lead in one of the upper chambers that needs pushing and the M1 surface rift was only partly explored. Several deep holes in the rift await further exploration.

The cave in M1 doline was named Mozpot after the prolific growth of moss in the doline, and the fact that it occurs in Mozambique. The discovery of the M1 Doline and the subsequent cave were a surprise because it had previously been thought that Z1 gulley marked the eastern limit of the Frontier Shafts area. It now appears that the area may yet reveal further surprises.

The Final Push in Mozpot

D.P. Ward

The main focus of activity during the final week of the expedition was on Mawenge Mwena. However, after several days of sporadic exploration of Mozpot, the bottom had still not been reached. The final chance to push and de-rig Mosspot came on Monday 23 August, the day before the final 15 hour push to de-rig Mawenge Mwena. After being told by J-P Le Roux that nobody else wanted to go to Mozpot with Alistair Koliasnikoff, I reluctantly agreed to accompany him. I was actually glad to go, as I could not have spent another day in my tent, waiting for the weather to clear. By now the smell of my damp oversuit was too overpowering in a confined space.

I trudged off into the enveloping mist following Koliasnikoff, who thankfully led the way through the mist. At last, after climbing through a narrow, doorway-like gap in the rocks we emerged in a lovely, misty, fern and moss covered, vertical-sided doline. Koliasnikoff, who was already equipped, descended while shouting advice about rope-protectors and slippery moss. I put on my gear and followed. I was slightly apprehensive at the thought of abseiling onto a small pinnacle of rock that rose out the doline, but the apprehension soon gave way to awe at the breathtaking beauty of the moss and fern covered boulders in the doline, surrounded by drizzle and swirling mist.

The inside of the cave was no anti-climax either. The rock is mostly white and clean and well worn by water and there is a lot of running water in the cave. From the first cavern there is a lovely view of the doline and above the cave entrance there are moss and fern festooned boulders and trees. Climbing down between some white boulders, we reached the neat 4 m SRT pitch. The smooth walls are just too far apart to chimney climb. The rope was about 5 m long and hung into a pool of clear water, into which Koliasnikoff had earlier abseiled, complete with one of the drills. After another scramble down between well worn rock next to a waterfall, the next pool was reached. Above this is the "Sling-Swing", for which we had to leap, Tarzan-like, to swing feet first towards a boulder on the other side of the pool.

Descending further between boulders, we crossed the chamber and squeezed through two small sections in the boulder choke. I reversed into these and scraped my battery and SRT gear against rock at each squeeze, the rubber battery belt being seriously stretched in the process. My Petzl Croll also no longer looked shiny and new ! I emerged onto a sloping boulder and looked down at Koliasnikoff, who was messing about at the Y-hang above a fairly deep rift that had a central sloping ridge running away below. At the bottom of the rift there were two pools of water on both sides of the ridge, and a huge waterfall was hissing and roaring below us.

I looked at the upper rungs of the ladder which disappeared from view over the edge of the central ridge. Koliasnikoff was grimly tugging at the top of the ladder, which was quite stuck on a rock below. It took some time to free, and he had to rig a rope to abseil down the ridge and free the obstruction. I coiled the ladder and waited while he negotiated his way down to the stream-bed on the left hand side of the ridge, which ends in a waterfall some 3 m high. A circular pool has been eroded in the rock at the top and there is a small blocked hole in the bottom of the pool, which is halfway between the top of the waterfall and the stream-bed at the bottom. Koliasnikoff said that it reminded him of the Dutch boy who saved Holland by putting his finger in a hole in a dyke.

Koliasnikoff explored the stream-bed and it sounded like he threw some rocks down a choke at the far end. He later explained that the boulder choke had actually collapsed from under him when he moved a rock. He reappeared as I was munching a Mars Bar and had just lit my reserve candle to warm my hands, and then disappeared again. My hands were so numb that I was able to hold my fingers in the flame and I was pondering whether I could actually dry my hands like that when Koliasnikoff shouted above the roar of the waterfall that I should descend. I dutifully abseiled down the rope into a

stream-bed, doing the last last part of the abseil with my feet on the far wall, eventually ending up upside down with Koliasnikoff pulling the rope clear of the wall. This resulted in the unpleasant feeling of cold water running out of my boots and down my legs, but I fortunately reached the stream-bed before the water reached my privates.

I assessed the next boulder choke and refused to go down, as my arm had been hurt while lifting myself off a cowstail on an earlier abseil. Koliasnikoff went down with my more powerful mining lamp and, after a long time in which he crashed more boulders about, he asked me if he would sink if he swam across a pool he had discovered. I shouted back into the darkness that his wetsuit would give him buoyancy, but that he should remove his boots before proceeding with his swim. He did so, and crossed the pool to find another boulder-choke. During the long wait I whistled a mindless tune, and was so cold that I could not concentrate long enough to change to another tune when it became boring. Eventually I saw Koliasnikoff approaching, covered in flecks of dried foam. The cave went no further, and the terminal pool sumped.

Koliasnikoff was miserable and cold after his swim and rapidly made for the stream-bed and the rope pitch up the narrow crack to the ridge. He paused at the top of the waterfall and blocked it so that I could prussik back without getting too wet. I was most grateful. He then proceeded to the top of the pitch, gathered some rope and bolt bags and hurried off through the choke. I got off the ridge by accident, resulting in a tight prussik in the right hand crack. I then de-rigged the pitch and stuffed the rope bag while standing under the waterfall. Water pelted my oversuit looking for a way in, but I was happy to find that not much water could penetrate to my woolly undersuit.

I cursed my way through the squeezes and found that Koliasnikoff had gone ahead. I made my way up the sling and found Koliasnikoff stuck there. His carbide light had gone out in the waterfall and his back-up electric light was not working. I lit the way for him so that he could get through and we wearily made our way to the next short pitch. I de-rigged this too, and joined Koliasnikoff in the entrance chamber.

Koliasnikoff started on the pitch out of the doline. We had decided not to de-rig the doline pitch as we were both too tired and our bags were already too heavy. He seemed to struggle a little at first, due to the heavy bags, while he negotiated the mossy boulders and vertical wall. He then pointed out, very considerately, that the slim arch to which the deviation was attached was holding up a huge ALB ("Amazing Levitating Boulder"). I immediately crossed to the other end of the chamber and reflected on this comment. "What the hell! If it comes down, it comes down", but I was glad when Koliasnikoff was past the deviation.

I was in such a hurry to get out that Koliasnikoff had to chase me off the rope so that he could lift it up to change over to the next pitch. Eventually the "rope free" call rang out in the doline and I prussiked into the eerie misty moss and ferns. I was glad to be on my way out, but my sore arm soon ached from pulling the rope through my Croll. I stood briefly at the top of the pinnacle of rock and wondered again at the beauty of the doline's size and impressive grey, eroded walls. I felt momentarily glad to have gone caving, but came back to reality with the weight of my bags as my arm again requested light duty. However, the final pitch went quite quickly and I was soon climbing out over wet and slippery boulders.

Koliasnikoff and I stumbled through the rock doorway and into the enveloping mist. We struggled at times to put one foot in front of the other without falling over. Crossing a small stream, Koliasnikoff put a foot wrong and sank up to his waist in a crack. In trying to assist him, I put both feet in the crack and we floundered about for a while. The last little uphill slope to the camp site loomed in the mist, and I muttered curses under my breath as I puffed my way in bottom gear up the hill. Although tired, we were both in good spirits when we reached the camp site. We joked with David Harley, and Tim Truluck took some portrait shots while we sat on a rock outside his tent. I contemplated a joyful leap over Harley's tent, but decided against it after he threatened me with grievous bodily harm. Instead I gratefully changed into some dry clothes in my warm, but still smelly tent, a sore, tired, but happy caving experience tucked away in my memory.

Mawenge Mwena (Z9)

J.P. Aucamp

The Z9 rift, named the "Rift Mother" by J-P Le Roux, is a huge rift cutting into Turret Towers from nearly the top of the mountain, running all the way down until it eventually spills into the Z3 doline. At the lowest point of this rift is the entrance to Mawenge Mwena. Initially, the "Rift Mother" was found by Tim Truluck, J-P Le Roux, Darryl Holland and John Grindley during a walk on the western buttress of Turret Towers. The route to "Rift Mother" involved a long and tedious walk up the mountain impeded, by many rifts en route, resulting in it taking nearly two hours to reach the top end of the rift. J-P Le Roux's and Stuart Page's subsequent exploration of "Rift Mother" revealed it to be a deep and lushly vegetated rift requiring many short lengths of rope to negotiate the many short drops caused by choking. They had pushed down the rift a long way by 15 August, but no cave had been found.

I had spent a week of enforced absence from caving after very stupidly cutting my thumb down to the bone while trying to inspect the spark plug on the Honda generator. I was eager to go caving and decided to see if I could cave with only one hand and a few fingers. On August 18 I therefore joined Le Roux and Page in a bid to try and find a cave in the "Rift Mother". We slogged our way up the mountain, sweating considerably in the heat. We met a couple of retired National Park wardens wandering around and Le Roux somehow persuaded one of them to carry his tackle sack for him. Eventually we reached the first pitch into the rift ,and the National Park wardens said goodbye.

Progress down the rift is like real caving, as the walls often stretch 50 m up above, and the light is somewhat dim. In places you have to crawl under monstrous boulders and abseil short, narrow pitches between rocks. Eventually, a long, long way down the rift, we found a narrow entrance leading off to the right, and along a 7 m horizontal low passage, in which a couple of short pitches took us well and truly into the dark. With Page in the lead, we managed to pick a route down through the "Boulder Collapse Section" which consisted of loose boulders, rocks, and short 3-6 m pitches, eventually dropping to about -90 m.

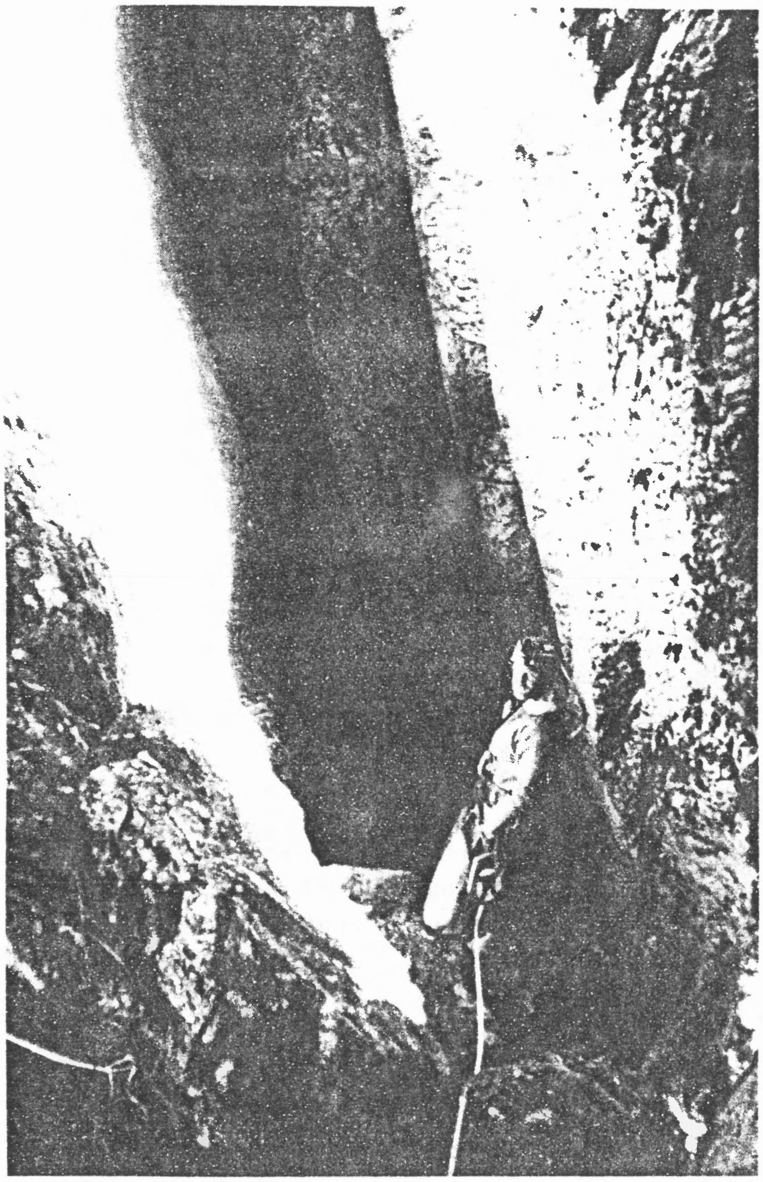
After a tricky 12 m abseil, the nature of the cave changed. The pitch dropped into a small chamber with well-worn walls and floors, named the "Lunchtime Chamber". A stream-passage with several pools led off from the chamber and there seemed to be a big pitch dropping away between some boulders in the bottom of the chamber. The Hilti drill was taken out and Page quickly rigged the pitch, which descended vertically for 34 m to a ledge and then carried on to a further drop. I joined Page on the ledge as he rigged on down. Eventually he reached a second ledge which held a suspended pool. He was out of rope, so consolidated his position, and we called it a day.

Back on the surface, we decided to try and find an alternative route out of the rift. We managed to climb up some boulders in the rift, which led to a saddle overlooking Z3. By placing a hand-line we managed to traverse round an exposed section to reach a parallel rift, from which we managed to reach a flat section which led us over a small ridge between Z3 and Z7 Dolines and back to the campsite. This route was much quicker and easier, although more exposed, than the original route via the top of "Rift Mother".

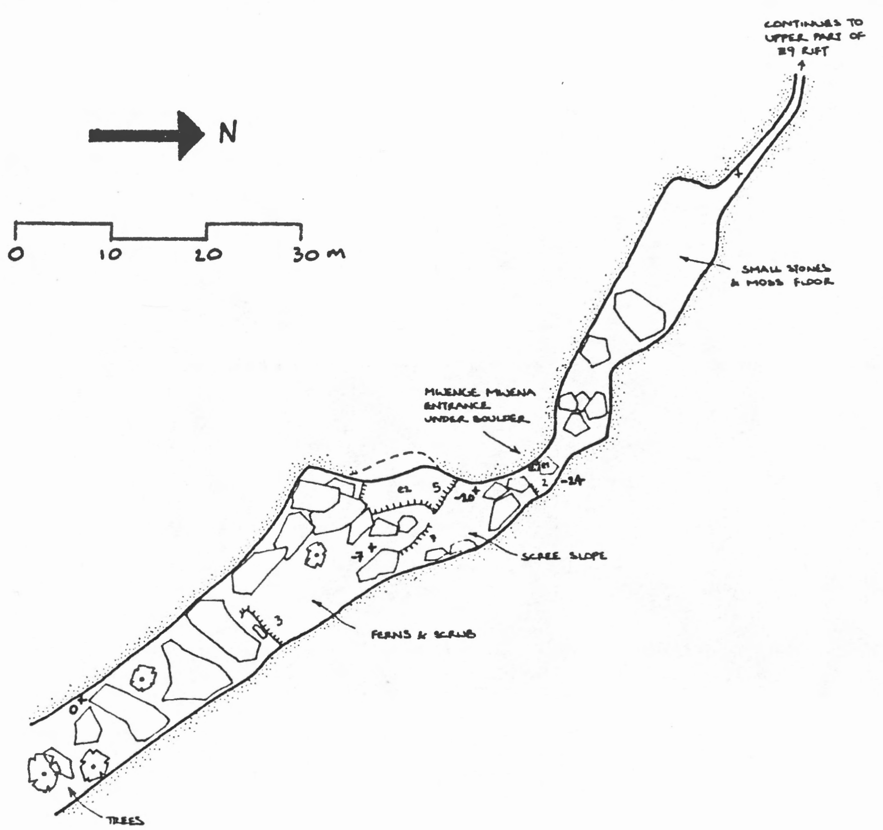
The next day, Page and I returned to push Z9 while Truluck and Le Roux surveyed down the rift from the top of Turret Towers. Page and I quickly reached the entrance by using the traverse from Z3 and descended to the ledge with the pool. This time we had plenty of rope, and Page dropped 7 m to solid ground. The cave at this point changed its nature again, becoming rather exciting as we followed the rift horizontally along a stream passage. This was the first real horizontal development that

I had seen in any of these shafts. However, after about 15 m it ended at the top of a 25 m pitch.

At the foot of that pitch we climbed down over boulders, following a howling gale to a narrow pitch head, nearly blocked by a large boulder. After several failed attempts to move it, Page managed to squeeze himself out and over the boulder, to find a massive drop on the other side. He managed to swing back underneath the pitch to place a re-belay which gave a good hang further down. However, he declined to descend as he was feeling somewhat isolated. He returned to me after a long hard struggle to get past the offending boulder. There then followed a long period of fun and games, trying to move the boulder away from the pitch head. Eventually we managed to place a bolt in the wall and in the boulder and, by setting up a 3:1 pulley, combined with lots of brute strength, we managed to move the boulder sufficiently far away from the pitch head to gain access. It was too heavy to move further, and too unstable to leave to its own devices, so we tethered it in place with a wire sling, earning it the name of "Rock on a Rope". It still rocked quite alarmingly when any weight was put on it, but at least it could not roll off down the pitch. We were now exhausted and out of rope again, so we headed back to camp for tea. Back in camp things were a little tense as Koliasnikoff and Harley, who had agreed to de-rig Black Crystal Abyss, had surveyed the Great Transvaal/Cape Rift instead. This meant that there was no more rope available to continue pushing Z9 the next day, and we had only a few caving days left. The following morning Koliasnikoff saved the day by waking up extremely early and pulled out some ropes from Bounding Pot.


J-P le Roux surveying in "Rift Mother". (T. Truluck)

Truluck and Le Roux, who were to survey the cave, accompanied us to the cave entrance, after which Page and I quickly returned to the tethered boulder. Page abseiled past a ledge with another pool, named the "Devil and the Deep Blue Sea", down a massive 70 m to a huge boulder across the rift. I joined him after a while and, although the cave felt like it was closing down, we had to go further to find out. At this point our usually trusty drill refused to work. I descended a little, trying to find some natural belays lower down. However, at this point there were several protruding quartz-veins in the wall, and the rope was rubbing far too much to get away with using natural belays, so we decided to leave the cave.



PLAN OF Z9 RIFT AT ENTRANCE TO MAWENGE MWENA

Chimanimani

Page ascended first and waited for me at the "Rock on a Rope". When I was half-way up the pitch, I could see a very nasty half metre rub point above me. Although there was a rope protector in place, there was so much rope stretch on this big pitch that it was effectively useless and the sheath was nearly gone in two places. I was within 2 m of the rub when the sheath gave way and started sliding down the core ! I let out a rather concerned expletive and managed to swing over into the narrow end of the rift while sliding down the rope, succeeding in wedging myself in the rift. Page had heard my shout and yelled down to me "Are you all right?" I could only reply a very worried "No!!!" I slowly gathered my composure and decided I had little choice but to prussik up the several metres of un-sheathed core stretching above me in order to regain the safety of the intact rope above. I tied a knot in the sheath below me so I could not slide any further down and gingerly attached my top jammer to the core. It gripped nicely and, standing up, I placed my chest jammer on it too. Very, very carefully I prussiked up the core, watching it rubbing and fraying on the rock above me. After what seemed like an eternity I managed to slide my top jammer onto intact rope, and suddenly felt much better about life. When I was high enough I tied a huge knot into the rope below me and shakily prussiked to safety. The pitch was subsequently named "Big Wanker" after the large rub point that caused the damage to the sheath.

We met Truluck and Le Roux at the top of "Lunchtime Chamber" and told them of the inci-

A few good men. The team of cavers for the last push in Mawenge Mwena: (l-r) Tim Truluck, Alistair Koliasnikoff, David Harley, Darryl Holland and Dave Ward. (J.P. Aucamp)

dent. They surveyed into "Lunchtime Chamber", before Truluck's miner's lamp failed and they returned with Truluck using his spare Petzl Zoom. I did not feel like caving the following day, but Truluck and Page returned to the cave and surveyed down to the "Devil and the Deep Blue Sea", removing the damaged rope. Page departed the following day, after naming the cave Mawenge Mwena. Mawenge means high place, and is the traditional name for Turret Towers (Nel 1993), and Mwena means "hole" in the local Shona language, so Mawenge Mwena, therefore literally means "high placed hole".

On Monday 23 August, Le Roux and Aucamp returned to the previous deepest point, but again the drill had refused to work. The cave was not yielding its secrets easily, and we had no choice but prussik back. It was an epic trip out as Le Roux's knee started hurting and became unstable. It was extremely painful and virtually useless. The cave was also much wetter, due to the previous night's rain, and the excess moisture in the cave softened the healing scar on my cut thumb. The wound quickly opened, also making it painful and useless. After slow progress, accompanied by much moaning and performing, we managed to get back to camp and decided to retire from caving for the rest of the expedition. The day was wasted, and we had only one day's caving left!

The last day dawned gloomily. There were only five fit cavers left: Truluck, Koliasnikoff, Harley, Ward and Holland departed at about 11h00 for Mawenge Mwena for a last push, and to complete the survey. Truluck, Ward and Holland remained in the upper sections to take some photographs and to help carry out gear during the de-rig, while Koliasnikoff and Harley descended to the previous deepest point. They managed to place a bolt, and descended to the bottom of the shaft only a few metres below where I had returned from the previous day. The cave then split into two narrow sections. The right hand, deepest one ended in a small square bottom, big enough for two people to stand. The other narrowed and became too tight although there may be a way on if a crowbar is available. It was the first cave to pass -300 m, bottoming out at a depth of -305 m, the deepest cave in southern Africa, but still some 65 m shorter than the world's deepest known quartzite cave in Venezuela.

Friday 13: Truluck, Holland, Le Roux and Grindley find top end of 'Rift Mother' while walking on the western buttress of Turret Towers.

Wednesday 18: Aucamp, Page and Le Roux explore 'Rift Mother'. Return with information that they have found an entrance to a cave. They rigged down to the pitch above the horizontal stream passage (-165 m). Truluck, Holland and Casalvolone complete the surface survey from Z7 to the top of 'Rift Mother'.

Thursday 19: Aucamp and Page continue exploration of Mawenge Mwena - reach and secure 'Rock on a Rope' (-195 m). Truluck and Le Roux survey the 'Rift Mother' and down the first two pitches in Mawenge Mwena.

Friday 20: Aucamp and Page continue exploration and reach 'Big Wanker' pitch. Drill fails and rub-point on rope occurs. Truluck and Le Roux survey down to 'Lunchtime Chamber'.

Saturday 21: Truluck and Page survey Mawenge Mwena to 'Big Wanker'.

Sunday 22: No caving in Mawenge Mwena. Weather closed in and it rained for over 24 hours.

Monday 23: Still raining, but Le Roux and Aucamp try to get to bottom of Mawenge Mwena. They are thwarted by the drill not working and injure themselves leaving the cave.

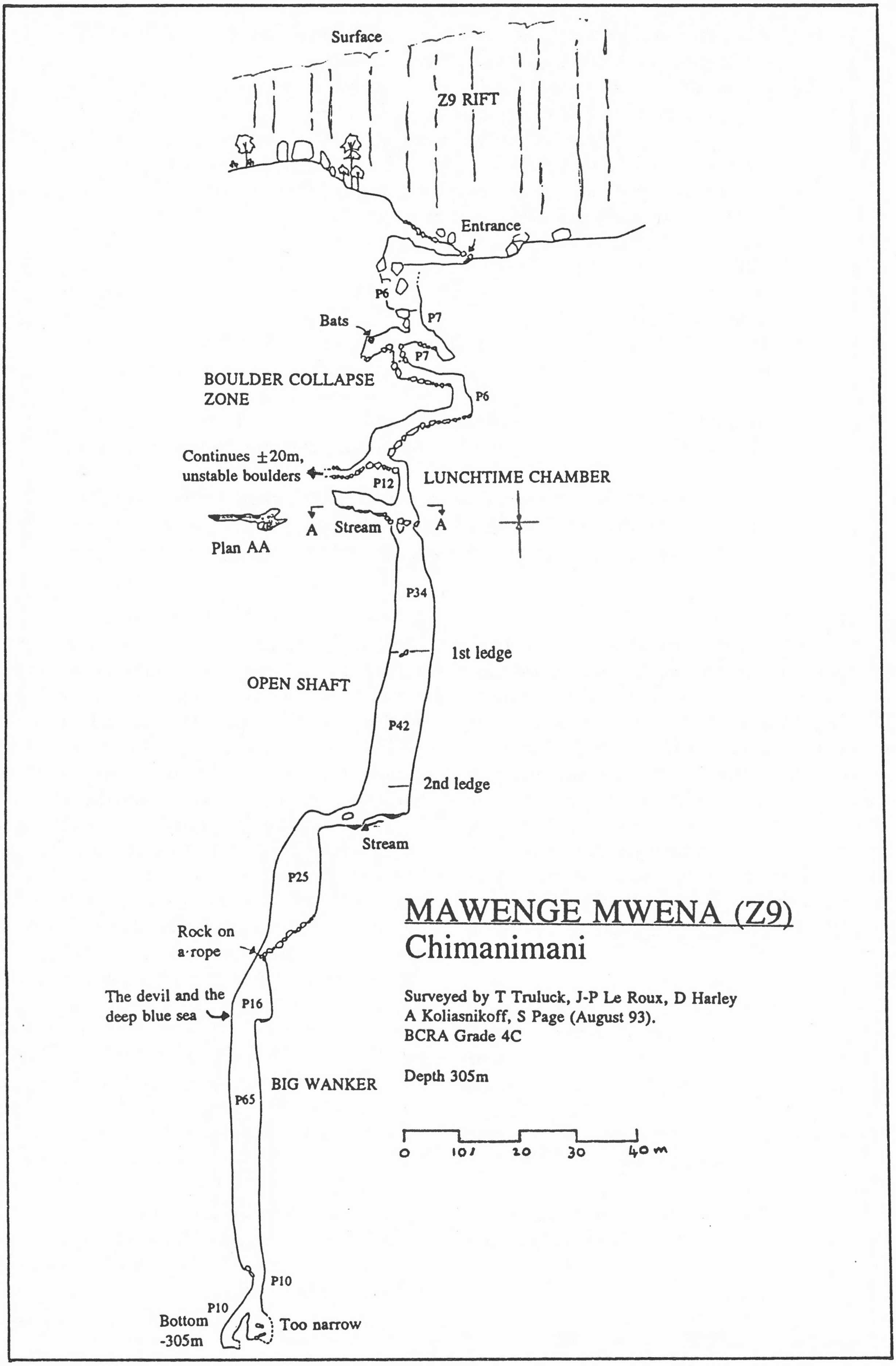
Tuesday 24: The final day of caving. Truluck, Harley, Koliasnikoff, Holland and Ward get to bottom and derig Mawenge Mwena during a mammoth 15 hour caving trip.

As they were preparing to return to the surface, Ward joined them at the bottom and helped them carry out the gear. Truluck, who had waited in "Lunchtime Chamber" then took out some of the gear, following Holland, who had already returned to the entrance with the photographic equipment. Truluck and Holland then returned to help the others with the remaining rope bags. The party was, by now, very tired and short-tempered, and it was past 23h00 when everyone reached the entrance. They still had to carry all the gear out of the "Rift Mother" via the front entrance, as well as de-rig the various handlines.

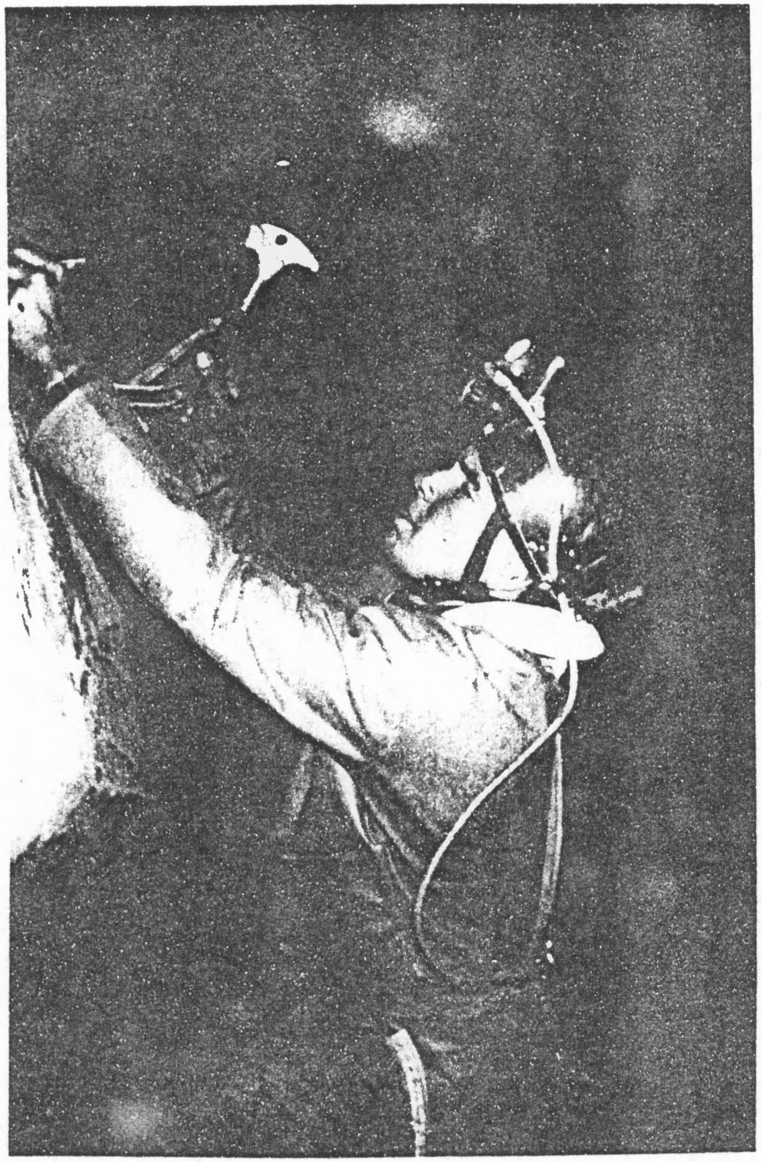
While Koliasnikoff was de-rigging the handline at the exposed section above the Z3 Rift, he slipped off a small ledge while trying to stop his caving bags from falling. He fell about 5 m and swung into the cliff face, hitting the rock with his helmet. The rest of the cavers had meanwhile been waiting on a buttress overlooking the Z3 Rift. They heard a plaintive cry for help from Koliasnikoff and Ward and Harley went to his assistance, managing to pull him up after about 45 minutes. Luckily he was not injured, but it was clear that the whole team was exhausted.

By this time it was after 01h00 and a thick mist had descended, reducing visibility to a few metres. Luckily Truluck, who had conducted the surface survey knew this part of the mountain and managed to guide the team past the treacherous Z3 and Z7 Dolines. The previous day, Le Roux and I had got lost in the mist and had almost met our maker while trying to scramble down into the 30 m deep Z7 doline. The party eventually reached the camp site at 02h00. Meanwhile, the surface-bound team had prepared a celebratory cocktail party. It had been ready for over 6 hours while they waited for the cavers to return. The private alcohol and luxury food stocks of the expedition members had been raided, and the spread was a truly inspiring sight for the tired and hungry cavers. After entering the final survey data into the computer, we calculated the official depth of Mawenge Mwena as -305 m, a very sound new southern Africa depth record ! The resultant party finally ended at about 04h00, when the cavers collapsed into their tents, only to be woken up by the arrival of the porters at 08h00.

***Deepest cave in southern Africa**
***Fifth longest cave in Zimbabwe (622 m)**
***7th deepest quartzite cave in the world**
***8th deepest cave in Africa**



Mawenge Mwena (Z9)



Stuart Page places a bolt in Mawenge Mwena. (J-P le Roux)

Stuart Page and Pete Aucamp inspect the 1·5 m rub-point from "Big Wanker" in Mawenge Mwena. (T.F. Truluck)

The Weathering of Quartzite

T.F. Truluck

Galan and Urbani (1987) note that there are few data concerning weathering and landform development in quartzite, and the mechanism of weathering remains poorly understood. However, several recent studies, most notably on the quartzites in southern Venezuela, have begun to shed light on the weathering processes involved.

Low Solubility of Quartz

Despite the fact that silicified sandstone is highly insoluble, the forms developed in it may be characteristic of karst landscapes in calcareous rocks (Busche and Sponholz, 1992; Briceno and Schubert, 1990). In fact, given the appropriate environmental conditions, almost any rock can be modelled to karst forms (Briceño and Schubert ,1990). Several authors have found it difficult to reconcile the low equilibrium solubility of quartz (6 ppm) indicated by experimental studies with the well-developed 'karstic' terrain found in south-eastern Venezuela (Galan and Urbani, 1987). Table 1 indicates the common range of abundance and solubility of some representative minerals. Due to its highly siliceous, well-cemented character, quartzite is one of the rocks most resistant to weathering.

Field measurements of dissolved silica on Mt. Roraima in Venezuela indicate that the surface waters contain very low levels of dissolved silica. Running water and pools on the summit contained less than 1 ppm, while those at the base have 5-7 ppm of silica, presumably due to longer residence time within the quartzite mass (Galan and Urbani, 1987). The solubility of silica is therefore very low in meteoric waters (Ford and Williams, 1989). However, in a study of sandstone caves in eastern Niger, Busche and Sponholz (1992) note that the ground water-saturated zone of the region contained 10 000 ppm of SiO_2. Such extremely high levels of silica in the ground water are unusual. Perhaps there are fewer competing minerals to be dissolved in this desert region, and so more silica is dissolved. However, the low solubility of silica may not be an impediment to the development of karst forms when enough time and water are available (Briceño and Schubert, 1990). Although the dissolved silica concentrations in water collected in quartzite rocks are usually low, the total amount of silica removed each year could still be considerable in cases of high rainfall (Galan and Urbani, 1987).

According to calculations by Martini (1981), the micro-solution of siliceous cement could extend a fracture in quartzite to a depth of 100 m over a period of 300 years. Briceño *et al* (1991) note that rock weathering to produce detritus that can be transported by the erosive agent only requires solution of this cement, constituting about 20% of the total rock. They calculate that, if this process were 100% effective, 105 tons per km^2 per year could be lost to weathering under rainfall conditions of an average 3 500 mm/year, producing a denudation of 2 800 m in 70 million years in Venezuela. However, they recognise that climatic conditions have not been constant, that the process is not 100% efficient, and that the concentration of SiO_2 in the water barely reaches 6 ppm. However, not all the rock need be converted into sand, and concentration of water flow along fractures and bedding planes, with consequent collapse of rock, accelerates the rate of denudation.

Mechanism of Quartzite Weathering

Galan and Urbani (1987) state that the mechanism of quartzite weathering in Venezuela appears to occur primarily by direct, slow solution of quartz. Chemical alteration of the small amounts of feldspars and micas present in the rock also plays a part in rock breakdown. Quartz sand grains

released by weathering of the quartzite show clear evidence of solution in the form of crystallographically-controlled etch pits. In thin section, weathered quartzite appears more porous and less well-cemented than the un-weathered rock. The surfaces of the overgrowths on grains have begun to dissolve, leaving narrow voids between the grains. Loose sand grains can easily be rubbed off with the fingers on rock samples, and the rock can readily be crushed due to widening of micro-cracks by solution. Cracks of all sizes in the rock act as foci for water flow and these cracks therefore experience preferential solution.

Chemical Weathering and Products

Chemical weathering is controlled by a combination of organic and inorganic factors. Rainwater, with its low pH, constitutes an aggressive chemical agent that affects sandstones (Briceño *et al,* 1990). A number of authors have also shown that the solubility of quartz can be markedly increased by the presence of organic molecules, particularly alginic acids and amino acids (Busche and Sponholz, 1992; Galan and Urbani, 1987). On the summit of Mt. Roraima, Venezuela, such acids are released in abundance by algae which coat the rock surfaces, and by the bog vegetation within the depressions (Galan and Urbani, 1987). Busche and Sponholz (1992) conclude that in the sandstone caves of eastern Niger, in the hyper-arid Sahara Desert, it was not merely the specific acidity level of the ground water that facilitated the development of surficial and underground forms of silicate karst, but that solution was facilitated and accelerated by various organic acids.

Weathering of silica, and its migration along joint systems and bedding planes, is shown not only by the widening of these structures near the surface, but also by the development of silica encrustations in the form of lattices, as well as by the presence of speleothems (Briceño *et al,* 1991). Briceno and Schubert (1990) claim that climate exerts a determinant effect on the erosional processes as well. The abundant rainfall contributes not only to the chemical degradation of the rocks, but also to the removal of clastic material. The water preferentially dissolves the siliceous cement of the sandstone and produces a porous, permeable, and friable material, which, when de-segregated, forms sand that is easily transported by run-off.

Conclusions

Studies investigating the solution of quartzite and formation of karst-like topography in quartzite rock remain rare. However, the pioneering and ongoing research in Venezuela has provided valuable insights into the development of pseudo-karst features. It seems that, given time and the correct environmental conditions, silicious rocks can develop such features. The caves in Venezuela and Chimanimani, as well as elsewhere in world, provide ample evidence of this. However, more research is needed in the other areas, such as Chimanimani, to complement the work carried out in Venezuela.

Table 1. Dissociation reactions and solubilities of some representative minerals that dissolve congruently in water at 25 °C and 1 bar (101.3kPa) pressure (from Ford & Williams 1989, after Freeze & Cherry 1979).

Mineral Meteoric Waters	Solubility at pH7 (mg/l)	Common Range of Abundance (mg/l)
Gibbsite	0.001	Trace
Quartz	12	1 - 12
Amorphous Silica	120	1 - 65
Calcite	100*, 500+	10 - 300
Dolomite	90*, 480+	10 - 300
Gypsum	2 400	0 - 1 500
Sylvite	264 000	0 - 10 000
Mirabilite	280 000	5 - 10 000
Halite	360 000	5 - 10 000

(* $P_{CO_2} = 10^{-3}$ bar, + $P_{CO_2} = 10^{-1}$ bar)

The Formation of the Frontier Shafts

T.F. Truluck

The occurrence of karst-like or pseudo-karst features in siliceous sandstones is well documented. Pure quartzites and silica sands cemented by silica can develop a wide range of solutional karst landforms at all scales (Ford and Williams, 1989). Karren grooves and other small-scale karst features related to surficial weathering are a common occurrence on solid rock sandstone (Marker, 1976). However, large sandstone and quartzite karst is comparatively rare, but may be spectacular, as in the great shafts of the Sarisariñama Plateau in Venezuela (Ford and Williams, 1989).

Despite the occurrence of such features in siliceous sandstone, Ford and Williams (1989) claim that the dissolution process is rarely predominant on these rocks. Therefore, at the global scale, these karst landforms are considered rare and of minor importance to speleologists and geomorphologists. Consequently, very little research has been undertaken to determine the processes and mechanisms of the development of siliceous sandstone pseudo-karst topography.

Until the early 1990s, the only area in the world which was known to contain quartzite caves with any significant vertical development was in Venezuela. This caving area is located in the remote south-eastern province of Bolivar. Exploration since the 1970s has revealed the existence of massive sink-holes and narrow inter-linked cracks. These sink-holes are the deepest quartzite/sandstone caves in the world, and some of the horizontally linked cracks may be the longest as well (Inglese and Tognini, 1993; Urbani, 1978). Each new exploration reveals more caves and shafts in this area.

However, with the discovery and subsequent exploration of the deep caves in the white quartzites of the Frontier System in the Chimanimani Mountains, another important quartzite caving area has been established. The caves in the Chimanimani Mountains are not open sink-holes or long cracks, but are properly formed caves, with doline entrances, pitches, waterfalls, passages, boulder-chokes, squeezes, and other features that a caver would expect to encounter in caves formed in limestone. These two major vertically developed caving areas indicate that significant and different types of caves may form in siliceous sandstone. It is therefore interesting to compare data from studies in the Venezuelan siliceous sandstone with information collected on the 1993 Chimanimani Caving Expedition.

Geology of the Zimbabwe Frontier System

The Chimanimani Caves are located in the eastern section of the Turret Towers massif. Turret Towers is part of the Frontier System, a name given to the rocks of the Chimanimani Mountains which extend for 50 km from north to south in Zimbabwe, and continue into Mozambique territory (Swift 1961). The Turret Towers massif is comprised of a thrust-block of white quartzite overlying two further thrust-blocks of red, ferruginous quartzite which, in turn, lie on a base of white quartzite (Watson, 1969). These thrust-blocks of quartzite are all supposed to have been deposited about 1 800 m.y. ago in a shallow to deep water, high energy environment (see Table 1) (Watson, 1969), and have been subjected to much tectonic activity since deposition. Following the folding and faulting of the Umkondo Period, there was a long period of erosion which continued well into the Mesozoic Era. The post Mesozoic history of the area is one of faulting, uplift and further erosion (Watson, 1969).

Development of Sandstone Pseudo-Karst

Ford and Williams (1989) list three principal requirements for the full development of sandstone pseudo-karst:

1. High mineral purity: Ford and Williams (1989) note that a high mineral purity ensures that initial solution channels do not become blocked by the insoluble alumino-silicates that are present in a majority of sandstones. A petrographic study reported in Watson (1969) of the Lower Quartzites from the Binga Massif indicate that the groundmass is of sub-angular to sub-rounded quartz grains, varying in size from 0·2 to 0·5 mm in size. Interstitial material is subsidiary, and is usually finely granular iron oxide and a little chlorite. The quartzite rock which comprises the Lower Quartzites appears to be of a very high mineral purity, and so the rocks of the Chimanimani Mountains conform to this requirement. The Lower Quartzites weather to a soft, friable, and rather sugary rock (Watson, 1969), which is devoid of feldspars and contains only rare amounts of white mica.

Table 2. History of geological formations and events of the Zimbabwe Frontier Series (after Watson 1969).

RECENT
Soils, alluvium and calcareous tufa
Long period of erosion, regional faulting

KAROO SYSTEM (Carboniferous to Jurassic: 190-320 m.y.)
Not represented in the area
Long period of erosion

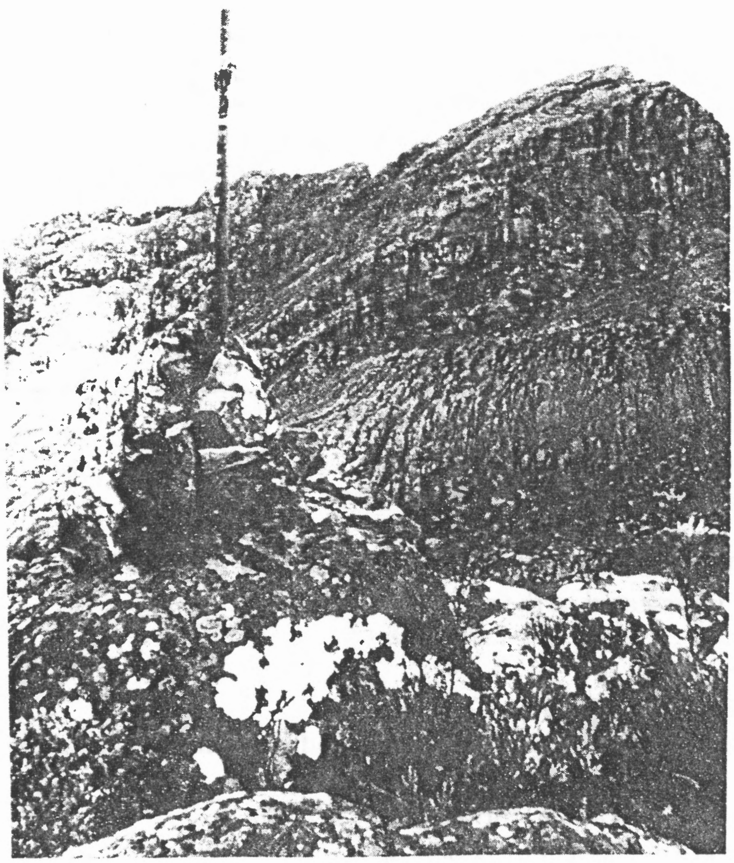
PRECAMBRIAN (>570 m.y.)
Quartz veins and associated copper and uranium mineralisation.
Regional faulting
Folding, thrusting and shearing
Low-grade regional metamorphism
Frontier Series thrust westwards

UMKONDO SYSTEM
Umkondo Dolerite sheets and dykes (1500 m.y.)
Intrusive contact
Upper Argillaceous Series
Quartzite Series
Lower Argillaceous Series
Calcareous Series
Erosion. Disconformity
Folding and metamorphism of Frontier Series
Frontier Series (1800 m.y.): Clean arenaceous and pelitic sediments, now represented by ortho-quartzite and chlorite schist
Granite batholith and pegmatite dykes
Gneiss in Mozambique (2530 m.y.)

BASEMENT SCHISTS (Archean: 2900-3200 m.y.)
Part of the Lower Quartzites of the Frontier System, and are between 300-600 m thick (Watson, 1969).

2. Thick to massive bedding with strong but widely spaced fracturing: The thrust-blocks of the Upper Quartzites, within which the caves are located, are 300-600 m thick. From the accompanying photograph of Turret Towers, these thick bedding planes may be seen. Another dominant feature of the Turret Towers Massif is the many fractures, which have caused deep, intersecting rifts and ravines.

3. Absence of strong, competing geomorphic processes, such as frost shattering or wave attack: The absence of effective competition permits the comparatively slowly developing solution landforms to become dominant (Ford and Williams, 1989). The rocks of the Frontier System seem to have been situated at a high elevation for much of their history. During the Karoo period, when massive deposition of quartzitic material occurred throughout southern Africa, the Frontier System was probably a source area for most of the Karoo sediments (Watson, 1969). It is thus unlikely that the Frontier Series was ever subjected to post-depositional erosion by waves of ocean currents. During the present winter period there are days when frost and ice form during the night. However, day time temperatures may also be over 30°C during the winter. It is thus unlikely that frost-shattering is a major competing process at present. Evidence of paleoclimatic patterns is rare, but there have been periods of glaciation in the past.

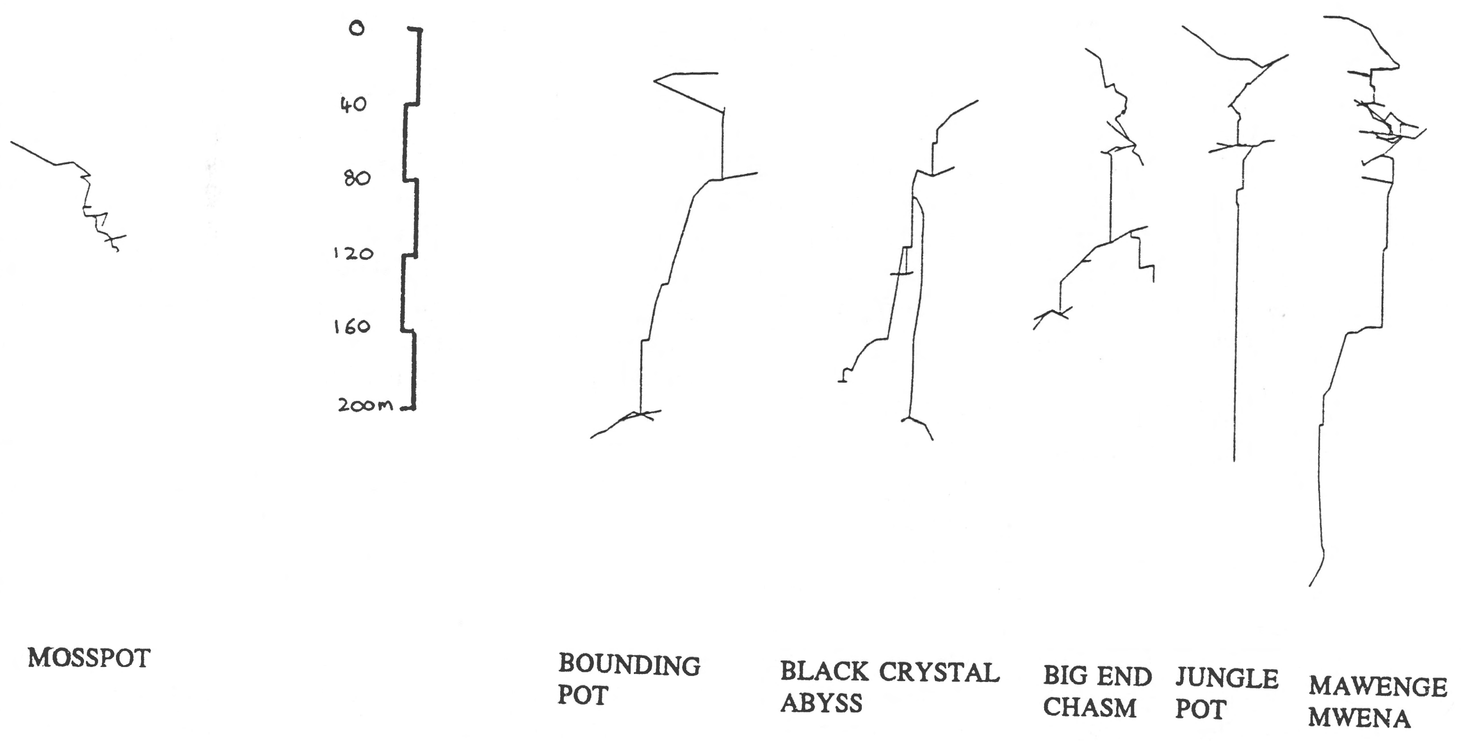


The rock strata of Turret Towers, viewed from Twin Peaks. (D.P. Ward)

The rocks of the Frontier Series are, however, very old, and it seems that there has been ample time for weathering processes to form a karst-like topography. The present dissected quartzite relief in Venezuela, which in some respects resembles karst terrain, has probably evolved by slow solution over many thousands of years (Galan and Urbani, 1987). Rainfall data on Turret Towers has never been collected, although Watson (1969) notes that rainfall in much of the higher areas of the Eastern Highlands is over 1·27 m per year. From the experience gained during the past three SASA expeditions to the area, the rainfall at Turret Towers is considerably higher than on the lower reaches of the mountains, where the rainfall data was collected. During the summer months, tropical cyclones sweep inland from the Mozambique coast and dump their rain on the Chimanimani Mountains, the first topographical barrier that they encounter (Watson, 1969). Even during the dry winter months, there is always running water on the surface and in the caves.

PLOT OF SELECTED CAVES, TURRET TOWERS
Chimanimani

SECTIONS



Physical Features and Sub-Surface Structures

Briceño and Schubert (1990) note that, on the table mountain summits in Venezuela, there are depressions varying in size from a few centimetres to hundreds of metres across. The largest resemble typical karst poljes, while the smaller ones occur on denuded rock surfaces or in the rocky beds of streams, and contain accumulations of sand, vein-quartz pebbles and discoidal sandstone shells covered with algae. In Chimanimani, similar features occur. Although there are few running surface streams, there are depressions of a similar size and range to those in Venezuela. Most of the streams have cut deep ravines and rifts along major faults and fractures, and the beds of these streams contain accumulations of sand, small to large well-rounded quartz rocks and quartz pebbles.

In Venezuela, caves are common near the table mountain rims, but are also found where structural joints and/or stratigraphic bedding planes or less

resistant units, channel the subterranean streams (Briceño and Schubert, 1990). Vertical development seems to be controlled by joint systems, and horizontal development by stratigraphy. In Chimanimani, no caves are found near the vertical rims of the scarps, but they are all located at the intersection of joints and fractures. These fractures typically intersect at right angles, and the resultant dolines often develop vertical caves at the bottom. This pattern of fractures at Chimanimani is clearly visible on the combined computer plot of all the caves at Turret Towers.

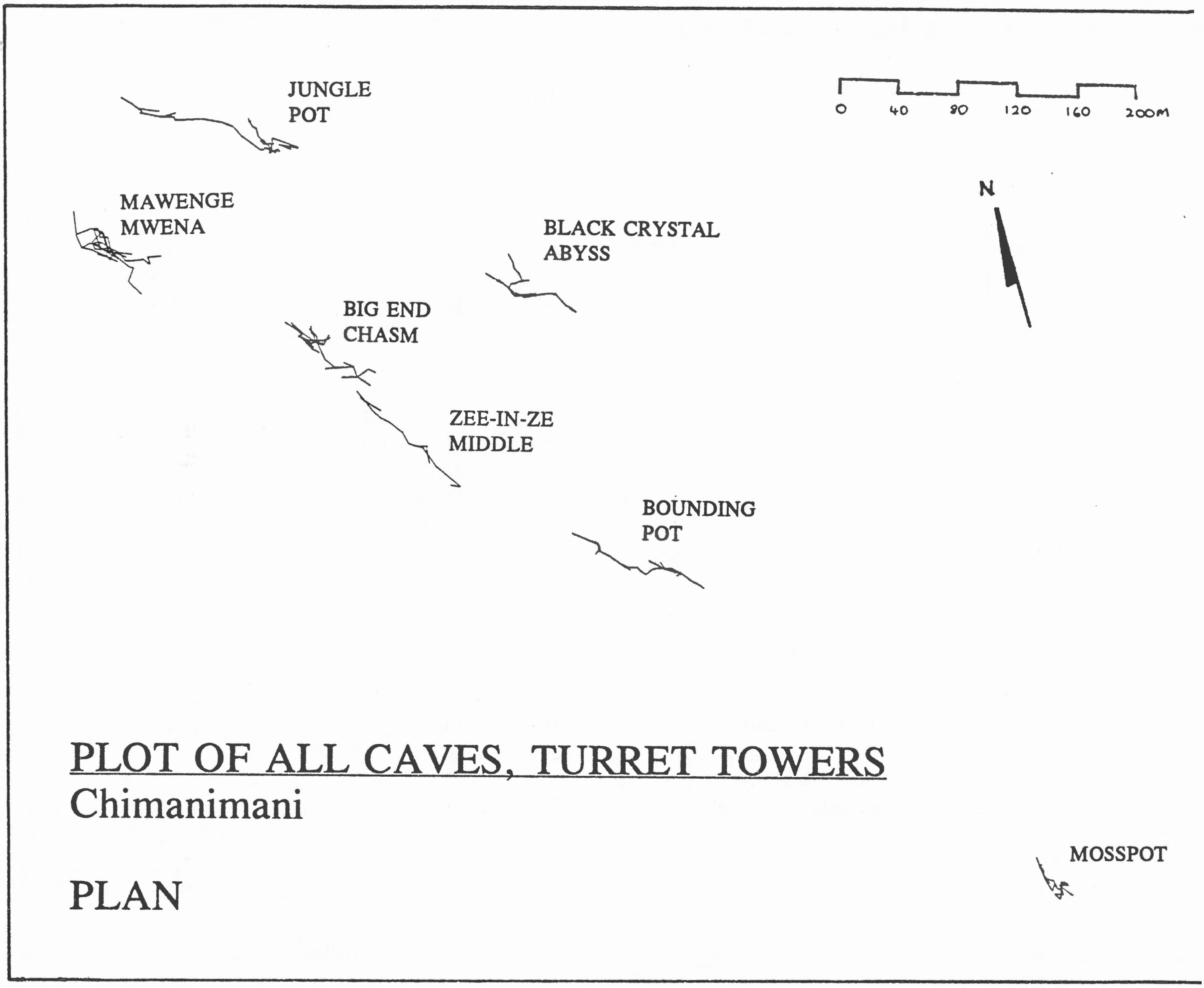
Sometimes the doline bottoms, such as those containing Black Crystal Abyss, Jungle Pot and Mozpot, are choked with large boulders and vegetation. However, some of the dolines , such as those containing Bounding Pot and Zee-in-ze-Middle, are unobstructed, and sheer cliffs must be negotiated to reach the bottom. Mawenge Mwena is the exception, being located at the bottom of a deep rift cut by a stream. However, even the entrance to this cave is located where the rift is intersected by a smaller fracture or fault.

Briceño and Schubert (1990) note that subterranean drainage is common on the table mountain summits in Venezuela. This can happen in two ways: i) Streams disappear under a thick cover of clastic materials, such as large blocks or boulders, which are larger than the stream's carrying capacity, and reappear hundreds of metres downstream; and ii) Streams converge towards a large fracture and disappear, forming large and intricate gallery systems which generally drain through the vertical walls of the mountains. Furthermore, groundwater flow is channelled by impermeable beds, causing the breakup of immediately overlying strata, a process responsible for the formation of gallery/rift systems and the collapse of caverns/dolines (Briceño *et al,* 1990). Both of the above sub-surface drainage patterns occur in Chimanimani. Streams have cut deep rifts, and often cannot be located in the bottom of such rifts, sometimes disappearing and reappearing. The streams in the rifts usually converge in dolines and disappear into the caves below, which are generally wet with pools of water, running streams and water running down their sides. In all the caves there was running water on the surfaces of the walls, with occasional small waterfalls cascading into the chambers below. There was also much evidence of mechanical erosion and deposition of material caused by water. Pools of water were commonplace, either in the sandy floors in the breakdown sections, in the rocky floors at the bottom of chambers, in scalloped ledges in the vertical shafts or in streams located at the bottom of several caves.

The walls of the lower vertical sections of were particularly well scalloped and eroded by running water. It seems that the running water weakens the surface rock on the walls by chemical means. The loosened material is then washed away during periods of increased water flow and is mechanically ground away by larger items of debris carried in the system. Mozpot, the "Long Drop" in Black Crystal Abyss, Bounding Pot and Jungle Pot (Le Roux *et al,* 1993) have flowing streams in the bottom, which all seem to disappear into inaccessible cracks. The only stream that was not located in the lower reaches of a cave was in Mawenge Mwena, where the vertical shaft becomes horizontal for about 15 m part way down, and one has to negotiate a tight stream passage before reaching another vertical section.

There are also streams in some of the flat, grassy sections, running below a jumble of quartzite boulders and debris. They can be heard, but not reached, and reappear and run along the surface when they leave the quartzite and encounter the chlorotic schists and sandy sections. In several caves there were upper sections which had developed in large amounts of breakdown material. These sections, especially in Mawenge Mwena and Big End Chasm, were very unstable. The upper 90 m section in Mawenge Mwena was particularly unstable, with several loose boulder chokes and large boulders which moved when touched.

In a combined computer plot of selected caves at Turret Towers, there seems to be a horizontal section at about -35 m. This horizontal section often manifests itself as a chamber, or, as in Bounding Pot, as the bottom of the doline. The line-survey of the caves clearly shows that this horizontal development is almost at the same level in all caves, and is probably caused by some structural mechanism, such as a horizontal bedding plane between two of the thrust blocks.



PLOT OF ALL CAVES, TURRET TOWERS
Chimanimani

PLAN

Conclusions

Studies conducted on the karst-like topography in Venezuela are applicable to the landforms found at Turret Towers in the Chimanimani National Park. The two areas seem to share several common features, such as dolines, surficial pseudo-karst and gallery or rift systems. The weathering processes of the silica also seem to be similar. However, many characteristics are different, the most notable example being the actual cave genesis and subsequent development. Further empirical scientific work needs to be carried out on the geomorphological and hydrological processes active in the Turret Towers karst-like topography to investigate the reasons for these differences.

The Fauna of the Frontier Shafts

T.F. Truluck

The 1992 Expedition to Chimanimani observed and collected a number of living creatures in the caves, and a special effort was made during the 1993 Expedition to supplement this collection with examples of all fauna in all the caves surveyed or explored. These samples form part of a baseline study on the faunal inhabitants of the caves, for comparison with any future assessments.

Insects and Arachnids

Samples of insects and arachnids found in the caves were collected and sent to the National Museum in Bloemfontein. They insects found were investigated by Dr John Irish, and the arachnids by Mr Leon Lotz, who identifed the following species:

1. An opilionid of the family Phalangiidae, resembling a spider but actually belonging to a group known as harvestmen, was found in semi-darkness about 3 m up a wall in the "Rift Mother", at a point where it narrowed to about 1 m wide and 40 m high. These insects often live in caves, but are not troglomorphic.

2. A rhinoceros beetle of the family Scarabaeidae, subfamily Dynastinae, was found at -50 m in the "Hall of the Lost Provita", Big End Chasm. This is not a cave creature, and was definitely a stray from the surrounding countryside.

3. Water beetles of the family Dytiscidae were found at -85 m in a pool of water in the small chamber below "Not a Ballroom" in Black Crystal Abyss. Similar water beetles were found at -120 m in a pool of water in "Hecate's Crack" in Big End Chasm, and at -125 m in a pool of water in "Toad Hall" Black Crystal Abyss. These beetles are not troglomorphic, but are apparently able to exploit the cave environment in Chimanimani.

4. Two brown crustaceans, probably family Isopoda, were collected at -35 m on the wall leading to the pitch over "Not a Ballroom" in Black Crystal Abyss. These are also not troglomorphic.

5. A centipede of the order Lithobiomorpha was collected at -100 m in "Hecate's Crack" in Big End Chasm. Similar species were also noted in Black Crystal Abyss (-70 m) and Mawenge Mwena (-75 m). The species was also collected in Jungle Pot during the 1992 Expedition. Both have been loaned to an Italian expert, whose initial opinion is that they are an un-described species.

6. A tiny, white, juvenile spider, probably of the family Anapidae but too immature to identify positively, was found in a stream passage at -175 m in Mawenge Mwena. This was also not troglomorphic.

7. A small brown beetle of the family Pselaphidae was collected at -75 m in Mawenge Mwena. These are also not troglomorphic, usually living in forest floor litter, although they occasionally enter caves.

Amphibians

An adult frog, *Rana angolensis*, was collected by Dave Ward and Darryl Holland at -130 m in "Toad Hall" in Black Crystal Abyss. This is a common species found throughout the African sub-continent, and tadpoles of the species were noted in pools in the same chamber and at -100 m in pools in a small chamber below "Not-a-Ballroom" in the same cave. The frog did not respond to light and had presumably grown from a tadpole in the cave environment. These frogs have a generalised diet. However, they do depend on vision for prey location, so would find it difficult to locate and catch food in a cave.

Bats

Very few bats were noted in the caves and only one or two insectivorous, black bats were noted in various parts of Black Crystal Abyss and Big End Chasm. However, Mawenge Mwena was an exception, and there were several clusters of small insectivorous bats in the upper sections of the cave. Two species, the black species and another, less common brown bat, were noted in Mawenge Mwena. Many bats were also seen roosting in the upper sections of the Turret Towers buttresses, particularly near the large cleft. A single insectivorous bat collected in Big End Chasm has not yet been identified.

Environmental Impacts

T.F. Truluck

In any wilderness area, it is important that human impact is kept to a minimum. From the outset, the expedition members were concerned that the human impact on the unspoilt Mawenge Plateau and Turret Towers should be minimised. Devising methods to minimise the impact of the Expedition started during initial planning and continued throughout the expedition.

Toilets Facilities and Camp Hygiene

Our first concern was sanitation and, after much debate, it was decided that two toilets would be used. Toilet seats were attached to milk crates, which were carried to the campsite, and two toilet areas were designated, with a 'key' system to ensure an undisturbed sitting. Each toilet had a 50 cm deep hole over which the milk crate was placed. The hole could not be deeper as there was very little soil covering the rocks. Every day some lime and a small amount of earth were used to cover the contents. Approximately once a week a new hole had to be dug, the old hole filled and the turf relaid. Men are notorious for urinating all over the place, and three weeks of indiscriminate urination in the campsite were considered undesirable. A urinal was therefore dug and filled with rocks, proving to be very successful. To minimise the risk of contamination, everyone was expected to spray their hands with a mixture of Dettol antiseptic and water after visiting the toilet. This appeared to work well, and no caver suffered from serious stomach complaints. The Dettol bottle was also useful for disinfecting cuts and scrapes that occurred while caving or hiking.

Disposal of Refuse

The amount of refuse generated by 15 people over three weeks was considerable. After consulting the attendant National Park ranger, it was decided to dig a pit and burn all combustible plastics, paper and cardboard every morning. Winter is the dry season in Zimbabwe, and the mountain vegetation was very dry and combustible. The fire was therefore kept small, and buckets of water and a fire-extinguisher were kept handy. Small amounts of paraffin were used to start the fire, but the fire was never left to burn unattended. Afterwards, the burnt material was lightly covered with soil.

On one occasion, some rubbish was burnt in the late morning. By that time the dew on the grass had evaporated, the temperature was warmer and a small breeze had arisen. Unfortunately, some sparks from the fire were blown onto the surrounding grass, setting it alight. Attempts to extinguish the flames using the fire extinguisher and water were ineffectual as the breeze fanned the flames and, in a very short time, the fire had become large enough to threaten the campsite.

The National Parks warden showed the three remaining cavers in the campsite how to beat out the fire using branches enclosed in heavy plastic dirtbin liners, but luckily the breeze changed direction and blew the fire back on itself towards the stream. The fire was then soon extinguished, leaving a 25 m x 25 m burnt scar. According to Stuart Page, who was head of the Chimanimani Outward Bound School for two years, fires are

commonplace during the dry winter months and the resultant scars heal quickly. After the fire, it was decided to burn rubbish only in the early morning when the vegetation is damp, never to burn rubbish when there was any breeze blowing and to burn small amounts of rubbish at a time.

All non-disposable material, such as glass, foil and thick plastic, was collected in a separate black bin liner in the communal tent. Porters who were hired for a re-supply mission halfway through the expedition were given these bags, in large orange porter packs, to carry down to Base Camp at the entrance to the reserve. The remaining non-disposable material was carried down at the end of the expedition. Used carbide was collected in a bin liner throughout the expedition, and nobody was allowed to dump used carbide in the veld, or in any cave. At the end of the expedition, the used carbide was deposited in the toilet and rubbish pits and covered with a thick layer of earth.

Littering was actively discouraged. All members of the team were prohibited from throwing away or burying any non-biodegradable or unsightly material. Everyone was encouraged to be continually on the alert for litter and, at the end of the expedition, an exhaustive operation was mounted using the 50 porters to comb the area and pick up all litter, leaving the camp area clean. However, one major source of litter was the porters themselves. We supplied them with Melrose cheese squares and Mars Bars, and those following behind the porters were continually picking up wrappers, cigarette butts and other litter. On future expeditions, consideration should be given to levying a 'littering penalty'.

Scavenging by Ravens

The Whitenecked Raven (*Corvus albicollis*) was the dominant bird in the area during the expedition. These are large, 40 cm high, black bodied birds with white necks and a large, heavy bill. They seem to be organised into small groups or pairs having their own territories, and were often observed chasing off other birds of prey. While walking on the steep and rugged slopes of Turret Towers we often watched their acrobatic and playful games.

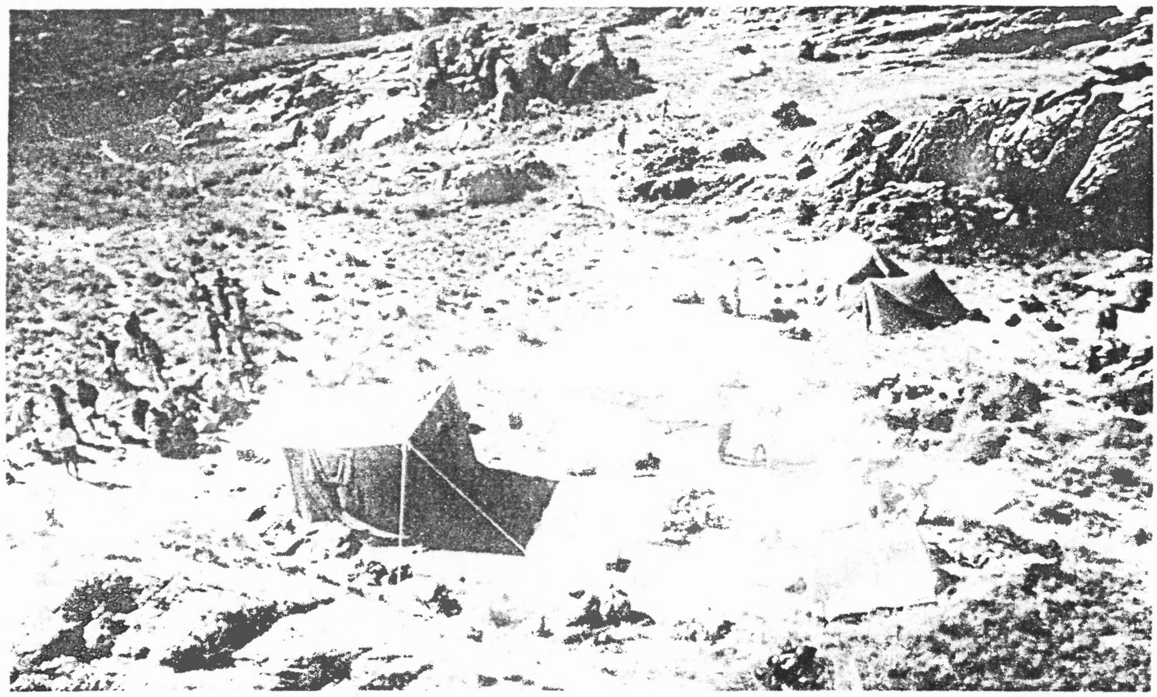
However, the ravens can be a great nuisance. They are very intelligent and efficient scavengers and, within a week, we had several resident ravens around the camp site. After 3 weeks we often had up to 50 of them waiting for food. If any box or packet containing food was left unattended or out in the open, the ravens would peck the container to pieces and eat the contents. They would even eat soap and wash sponges left in the sun to dry. Consequently, all tent flaps were kept closed and no food was left in the open. To prevent them from scavenging within the camp, all uneaten food was placed on a rock 75 m from the campsite. This rock was pecked clean within hours and, together with the rubbish pit, seemed to keep them from causing any damage in the camp area itself.

Another problem experienced with the ravens was that they scavenged any unburnt wrappers with food on them from the rubbish pit. As a result, small paper and plastic wrappers were rapidly scattered around the refuse pit by these birds. On several occasions we had to organise clean-up parties to pick up the resultant litter.

Impact on the Caves

As far as possible, damage to the caves and caving area was kept to a minimum. Specific paths and routes to the cave entrances were made to prevent excessive trampling of natural vegetation. The minimum amount of 'gardening' and pruning of the entrances was carried out. The Chimanimani caves themselves are formed in sandstone. Unlike limestone caves, which usually have delicate and fragile formations, the Chimanimani caves are generally just shafts or piles of boulders, so there is little physical damage that the cavers can do. Loose rocks and debris were removed from pitch-heads to prevent them from falling down the pitches, and some rocks and sand were moved to clear passages.

The unavailability of secure natural anchors on the smooth walls of most of the pitches necessitated bolts for rigging of the caves. Holes were drilled into which permanent stainless steel bolts were fixed. All bolts should therefore be adequate for subsequent trips. The few non-stainless bolts used, such as the Duplex Rawlbolts, were removed when caves were de-rigged. Litter, spent carbide and broken equipment were removed from the caves. Occasional calls of nature were answered in unobtrusive spots and never in running water.



The campsite on Mawenge Plateauon the last day of the expedition, showing the flattening of vegetation that occurred. (T.F. Truluck)

Apart from the few representative samples collected, cave fauna were left un-touched. We noticed that the hibernating bats in Mawenge Mwena were disturbed by passing cavers, but we think that they relocated themselves to quieter sections of the cave. None of the caves had large numbers of bats, such as occur in the caves in Zimbabwe's dolomite areas.

Flattening of Grass and Paths

The flattening of grass and the possible proliferation of paths was a continual concern of the expedition members. Unfortunately, an expedition of this size cannot avoid fairly severe flattening of grass in the camp site area. However, the camp site had been used on two previous caving expeditions, and the grass that was flattened then seemed to have recovered without any permanent damage. Future expeditions will be much smaller than this one, and we also we envisage a caving expedition to the area only every few years. This should minimise such negative impact on the camping area in future.

The potential proliferation of paths from the Bundi Hut to the camp site and then the caves themselves, was of great concern. From the outset, we clearly marked our paths with beacons and, in some cases, strips of silver paper attached to a rock. We think we were successful in limiting the number of paths to the minimum. Photographs taken at the end of the expedition clearly show the paths used, and there was no indication of dual or braided paths.

Washing of Cavers and Equipment

The washing of anything in the streams in the area was strictly prohibited, and buckets and bowls were provided for personal ablutions. Cavers washed and rinsed themselves out of a bucket on the stream bank. Kitchen utensils were washed in a bowl placed near the stream and dirty water was deposited in a drainage hole. Clothes were washed in a bucket. The caving ropes were rinsed in a stream on the caving side of the camp site, but these ropes only had mud and sand on their sheaths and their washing only resulted in a temporary muddying of the water.

Minimisation of Noise

Although we were in a remote area, we attempted to keep noise to a minimum. No tape recorders or portable radios were allowed in the camp, and the Honda generator that was loaned by Midmacor was the quietest in its range, being hardly audible 50 m from the campsite.

Food for Thought, and Caving

T.F. Truluck

In addition to seeking sponsorship for equipment, it was hoped that sponsors would be found for food supplies. In fact, we thought that we would have no problem in procuring food sponsorship. Although we eventually covered most of our dietary requirements via sponsors, we were initially rather worried about poor response from many of the larger food manufacturers.

Our first success was procuring 150 kg of 'Boil-in-the-Bag' rice from Tastic, Cape Town. After some pleading, the Transvaal branch also gave us some 'Savory Classics', a favourite meal of several of the cavers. This rice was the staple ingredient of our diet, being easy to cook, and not making a mess in the pot. One 125g bag was enough for a hungry caver. Our next major food sponsor was Bokomo in Cape Town. They provided enough breakfast cereal and porridge for the entire expedition, including oats, 'Weetbix', 'Honey Crunch', and the popular 'Mabel's Morning Munch'. The variety in cereals was appreciated on the mountain. Borden Foods agreed to supply us with 3 boxes of full cream 'Klim' milk powder, enough to make 800 l of milk. The 'Klim' powder was a superb product, being easy to transport up the mountain, easy to mix, and tasting like real milk. Melrose cheese squares were another favourite on the expedition. Melrose donated 2300 foil-packed cheese squares, which were used by cavers in the camp, in the caves and while hiking in the mountains.

Through the hard work of Kenda Taylor, David Harley, Tim Truluck and J-P Le Roux, we also started to receive a steady stream from small, but vital, food sponsors. Pako provided a selection of pickles and spices; Langeberg Co-op provided a box of mixed jam; Tuna Marine provided a selection of tinned meatballs and vegetable curries and Willards provided three cases of potato crisps. Maxims Packers provided quantities of the popular 'Shogun Noodles' and tinned tuna. Kurt Rietman gave a discount on salami and other processed meats, and their 'Happy Happie' meat sticks were excellent in the caves. Superior Beef and Biltong also gave a 50% discount on their excellent dried sausage and biltong (dried beef), also popular in the caves. Huletts provided sugar in useful, small catering sachets; Harmony Products provided 10 kg of pasta; Becketts donated tea and coffee and gave a discount on 'Pronutro', and Peninsula Beverage provided three cases of cooldrinks.

Interpex in Durban agreed to send us some soup packets, tinned mackerel (great fried in oil or added to the soya stew), and most importantly, vacuum packed, ex-army, pre-cooked meals. These were incredibly popular and were rationed out only to active cavers. These meals included chicken, pasta and meat and ham omelette, and the Maple Nut Cake dessert was worth going caving for. For many of us, these meals were the only real source of meat for 3 weeks. They could be eaten cold, or placed inside the oversuit, often along with the carbide generator, to provide warm and tasty meals while in the cave. They are highly recommended.

Another popular product was procured just before we departed. Royal Beech-Nut agreed to supply us with over 750 'Mars Bars'. This was wonderful

news, as compact high energy products are needed in the cold caves. In fact, Mars Bars are the standard British caving chocolate, being tasty, full of energy, compact and having a very strong wrapper. We had no success with any of the biscuit manufacturers in Cape Town. However, Pick 'n Pay in Cape Town, came to our rescue with R500 worth of shopping vouchers, which amply covered our biscuit and other requirements.

We also received a fantastic response from the manufacturers and suppliers of the various dehydrated soya or texturised vegetable protein (TVP) products. These products, along with the rice, formed our staple diet while up the mountain. As these products are often used by campers, hikers and cavers, I would like to review them individually:

Diva Products of Noordhoek, Cape Town, provided 1 kg packs of TVP with several different flavours. This was the product used as a base for 60% of our meals. It was difficult to distinguish between the different flavours, but it did not matter, as we always put in dried garlic, onion, other spices and other ingredients. For a large group, the large packets were very convenient.

Jabula in Johannesburg also provided a very popular TVP mix, which was well spiced and tasty. They also included some pasta, although extra had to be added to satisfy hungry cavers. Their 'High C' orange drink powder was also of a very high quality, and we always had a large container available in the campsite. This was also very popular when supplemented with vodka or other spirits.

Inani Products in Cape Town provided TVP mixes in small packets, each enough for 2-3 people. Their mixes were very tasty, and were a popular choice for those who wanted a lunchtime snack, or who were away from the main campsite.

Wonderfoods in Cape Town produce small, complete, dehydrated meals, each enough for two (or one very hungry caver). These were popular and convenient for quick meals while hiking and camping away from the main caving area. The left over packets were also useful on the long journey back to Cape Town. Finally, we would like to thank Mitchell's Brewery in Cape Town for providing us with two kegs of locally brewed beer for our welcome home slide show and party !

Packing the substantial quantity of food supplies and equipment into porter packs at the Chimanimani National Park base camp. (T.F. Truluck)

Management of the Chimanimani Caves

T.F. Truluck

It is fortuitous that the deep quartzite caves at Turret Towers are located within the Chimanimani National Park. As well as being extremely rare examples of quartzite pseudo-karst, the caves are also extremely dangerous, and access to them should be strictly controlled. The procedures to control access to these caves should be maintained through the National Parks Board, who should ensure that the caves and caving area remain off-limits to casual cavers and visitors. However, accredited organisations who wish to visit the caves for scientific purposes, should be granted access by means of a specific permit.

It is recommended that the following guidelines be followed in managing the Chimanimani caves:

1. The Chimanimani caves and their immediate surroundings are dangerous. Caving activities should be restricted to parties that have the necessary skills and equipment. It is unlikely, after the arrest of four cavers on the 1992 Expedition, that there will be further illicit caving trips (Le Roux *et al*, 1993). It would, however, be pointless to restrict access to hikers to the caving area behind Turret Towers. Very few people know where the caves are and it is unlikely that casual hikers will venture into the dolines.

2. The caves themselves do not contain formations similar to those found in limestone caves, although they do have an austere beauty as a result of their deep shafts and scalloped rock surfaces. They are unstable and contain much loose debris and weathered material, and would not be of any real interest to casual visitors, even if they could gain access to them.

3. The hydrological systems seem to be the key factor in forming the caves, and in providing water to resurgent streams on the plateau. These should not be polluted in any way.

4. Apart from the bats, the flora and fauna in the caves and the caving area do not seem to be troglomorphic, and it appears that most have been flushed into the caves during high flow periods. However, they should be protected as part of general faunal conservation measures for the Chimanimani National Park.

5. The caves should not be advertised in publicity brochures, and the locations should not be publicised.

6. Future caving expeditions to the area need not be as large as the 1993 one. Basic exploration has been completed and future expeditions should consist of a small, 4-6 person teams with specific goals.

Evaluation of the Hilti TE-10A Hammer Drill

D. Harley

Two TE-10A hammer drills were loaned by Hilti Fastening Technologies to the expedition, and were used over a three week period for bolting the caves. Five caves over 150 m deep were bolted, the deepest being 305 m. A total of six caving weeks of experience was acquired by two rigging teams, during which 1·2 km of vertical cave was rigged. During this period, considerable experience was acquired concerning the use of hammer drills for rigging caves.

The Hilti drill (see Table 1) is recognised as probably the best hammer-drill available for use in caves. However the cost of the drill is prohibitively high and many cavers resort to using cheaper alternatives (Williams 1993). The primary purpose of this report is to consolidate the lessons learned during the expedition and to provide a useful information summary for future users of the Hilti TE-10A in cave and cave-like environments.

Table 1. Technical specifications for the Hilti TE-10A hammer drill (Hilti 1991a).

Power input:	350 W
Battery voltage:	36 V
Speed under load:	750 rpm
Hole-starting speed:	200 rpm
Hammer speed under load:	4200 blows/min
Dimensions (mm):	334 x 65 x 240
Drill & battery weight:	4·2 kg
Battery life:	500 charge cycles

The most important lessons usually arise from negative experiences and, since it upon these that we dwell, it may appear that we have little to say in favour of the use of the TE-10A. Lest an incorrect impression be formed it must be stated from the start that our overall experience has been quite the contrary. We found the TE-10A to be an invaluable tool that, with suitable modifications and operating procedures, was indispensable to the success of the expedition.

Conditions in the Chimanimani Caves

The Chimanimani caves are vertical, with pitches sometimes exceeding 100 m. Most of the caves are wet, with water trickling down the walls and sometimes falling freely down the pitches. Generally the walls are quite clean, although, in drier areas, some mud accumulates. In all caves, wet quartzite grains stick to every surface, causing considerable wear on all equipment. The caves consist primarily of quartzite sandstone. In several areas veins of quartz and schist feature prominently. The composition of the rock is extremely variable, ranging from very hard, taking up to 2 minutes to drill a 12 mm, 5 cm deep hole, to very soft, taking a few seconds to drill a similar hole.

The water in the caves is extraordinarily corrosive. A single exposure in the caves causes galvanised bolts to discolour overnight, and steel maillons to develop rust spots. Any steel equipment left exposed for longer than three days develops rust covering half its surface. The average temperature in the caves is estimated at 15°C. At the head of the larger pitches there is frequently a draught, sometimes sufficiently powerful to blow out a carbide lamp flame. The direction and strength of these draughts was found to vary over a period of days.

Pre-Expedition Training and Testing

Before to the expedition, four training meets were organized in the sandstone caves of Table Mountain, Cape Town, which are very similar in nature to the Chimanimani caves. The purpose of these meets was to familiarise the expedition riggers

with the hammer drills and to establish good rigging procedures. We also wished to evaluate the equipment and test its robustness. During these meets we discovered and resolved a number of problems concerning the length of bolts required for certain hangers, the need for an adjustable spanner for the many different sized of bolts, gauging of depth for the expansion bolts and the need for wrist-straps for expansion bolt setters. The need for a second battery was also established

At one of the meets, a major breakthrough was made between two caves via a vertical squeeze, demonstrating the difficulty of using the drill in a 30 cm crack. It emerged, conveniently, at the edge of a traverse that had been bolted the week before. We also learned the meaning of false economy. As the traverse was being crossed, a R0·40 (£0·08) nylon buckle retaining the drill harness broke and the drill plunged down a 20 m pit.

Previous expeditions to Chimanimani relied on the standard Petzl M8 self-drilling anchors, which are inadequate in much of the softer rock to be found there. One of the most important aspects of bolting in sandstone caves is the reliability of different types of bolts inserted into bad rock. Although we had acquired the Hilti data sheets for the bolts that we planned to use, the data concerns mostly 'ideal' situations. We therefore obtained a bolt-tester from Hilti, which could exert a force of up to 16 kN perpendicularly from a wall, and tested several types of bolts under 'worst case' scenarios.

Several bolts were inserted into a section of soft sandstone which was crumbly, coarse-gained and made a dull sound when struck. The bolts were easy to insert, and the holes were slightly oversized as they abraded easily against the edge of the drill bit. The holes were also slightly wet. The results are given in Table 2.

We concluded that resin anchors were, by far, the preferred permanent anchor in bad rock. It must be noted, however, that the resin does not penetrate into the rock, but adheres to the grains on the surface of the hole, resulting in greatly diminished strength if the hole is not properly prepared. We also tested M12 cone anchors in fine grained, hard rock that gave a clear 'ping' when struck. The pull tests showed strengths greater than 16 kN, showing that these expansion bolts work well as long as they are only used in good rock. The end result of the training meets was that all the riggers were competent and familiar with the quirks of the drill. A design for a combined drill and rigging bag also arose directly from these exercises.

Description of Drill Use

Each rigging team was generally equipped with one drill, two battery packs, and a selection of 12 mm, 15 mm and 17 mm drill bits. The drills were transported through the caves in bags made of PVC with nylon backing. Both bag and drill were attached to the rigger by cords. When in use, the drill was generally clipped into the rigger's harness, and in vertical sections the drill was hung out of the bag for immediate use. The bolts used varied according to the composition of the rock and the rigging requirements. Those primarily used were M10 and ½ inch HKD expansion anchors, M10 double expansion Rawlbolts, M10 resin bolts, and M10 eye bolts.

Table 2. Pull-force tests for various bolt types under 'worst case' conditions.

Bolt Type	Force (kN)
M8 self-drilling anchor	Pull out by hand
½inch HKD expansion bolt	1.5
½inch HKD expansion bolt with resin	9.5
M8 sleeve anchor	3.5
M8 resin bolt in an uncleaned hole	5.0
M8 resin bolt in oversized clean hole	7.0
M8 resin bolt in cleaned hole	10.5

All caves explored were left permanently bolted. In situations where the rock was too soft to use a stainless steel HKD bolt, an M10 Rawlbolt was used as a temporary anchor and an additional M10 resin bolt was placed. The Rawlbolts were subsequently removed when the caves were de-rigged.

General Impressions of the Hilti TE-10A

The greatest liability in using the drill proved to be its weight. The drill weighs 2·6 kg, and the battery 1·9 kg, giving a total weight of 4·5 kg. An additional battery, plus drill bits and bolts, pushes the total weight to about 7 kg, which is a significant load to carry through a cave. It was also often difficult to hold the drill in position when drilling from an awkward angle.

Once in position, the drill performs extremely well and is a delight to use. We found that it generally took from 10 to 30 seconds to drill a hole. The use of a sharp drill bit was found to be an important factor in drill performance. We found that a single rigging session in the caves significantly blunted the bits, but that a bit could usefully be used for up to three rigging sessions. Contrary to expectations, no bit or drill attachment was dropped while being handled by the riggers during the entire expedition.

A single battery pack was generally sufficient for only 5 to 15 holes, making a second battery pack indispensable. A single rigging session usually exhausted both battery packs. Despite temptations to the contrary, the spare battery was generally carried by the rigger, as transferring the spare from the backup person was not always easy. The mechanical components of the drill, including the electric motor, proved to be extremely robust, and in six caving weeks gave no problem at all. The plastic drill casing also proved to be perfectly adequate, surviving considerable abuse with nothing more serious than a few scratches.

Problems With Using the Hilti TE-10A

Over the three weeks the drills were in use we encountered a number of problems which, with prior experience and adequate preparation, could have been avoided. These problems began to show up only after extensive use of the drills, and had not appeared in our practice sessions in the Table Mountain sandstone caves before the expedition. The main problems encountered were:

1. Unreliability of High-Speed Operation

The most annoying problem experienced with the TE-10A was the unreliability of high speed operation. On several occasions the drill was taken down a cave, and found to operate only on slow speed. As far as we were able to determine, the problem stems from three sources:

- The third small electrical connection on the base of the drill is unreliable. We found that it was sometimes necessary to bend this upwards in order to ensure a good connection. This problem was experienced independently by both rigging teams, and appeared in the first week of caving.

- The battery packs sometimes did not permit high speed operation, even though known to have a good charge. We found one battery pack (out of six) to have this problem more or less permanently. The remainder had intermittent problems. It is possible that this behaviour is caused by the batteries getting wet. We had conducted total immersion tests prior to the expedition, and had found that the drill switched to slow speed for about a minute before recovering normal operation. These results did not reliably repeat themselves down the caves, however, possibly because the high humidity and low temperature environment prevented the battery from drying out.

- Following an accidental dunking on the second last day of caving, one drill began to switch erratically between high and low speed before finally operating on low speed only. Dissection of the trigger switch revealed that a track on a small circuit board housed within the switch had failed. It was not possible to determine whether the track had fused, corroded, or simply been poorly etched.

This question of reliability is an important one. It can take several hours and considerable effort to get the drill to the point at which it is to be used, and when it fails to work it is not only frustrating, but wastes an entire day. More seriously, it places riggers in situations that encourage them to adopt

expediencies that are unwise and unsafe, and which would have been avoided had a working bolting kit been available. This negates the advantages offered by the more secure bolting system. At least three potentially hazardous rigging decisions were made during the expedition as a direct consequence of drill failure.

A comment here is also in order concerning the design philosophy of the TE-10A. The drill is an impressive electronic *tour de force*, incorporating electronic circuitry in rather surprising places. Presumably this improves the performance of the drill, but we cannot help wondering if this is at the expense of reliability. We would be happy to exchange a 20% improvement in battery life and electronic speed control for a drill that works even when it gets wet.

2. Battery Attachment Failure

A second serious problem with the drill was an apparent tendency for battery packs to fall off. On one occasion a battery fell off the drill down a 30 m pitch, surviving remarkably well, but becoming inoperative. On the last day of caving, a second battery was lost down a crack. On both occasions the drill had been operating for some time off the battery prior to its loss, and the riggers were certain that the batteries had been correctly seated.

Before and during the expedition we had assumed that it is necessary to press both tabs on each side of the battery simultaneously in order to release the battery. However, experiments subsequent to the expedition revealed that, with a little shaking, the battery can be released by depressing just the left button (drill facing forward). The battery is therefore not nearly as secure against accidental release as it might appear to be. To lose two batteries in six caving weeks is excessive, and it is our opinion that it is essential for the battery be independently attached in some way.

3. Poor Battery Performance

On a few occasions, the batteries delivered less charge than they should have. We eventually came to the conclusion that this was due to the batteries freezing overnight. Batteries were left on the charger with sufficient fuel in the generator to ensure they were charged in the morning. Overnight the generator would turn off, and the batteries would have an opportunity to freeze. Batteries that were charged in the morning and came warm off the charger always performed well. We were not, however, able to demonstrate conclusively that freezing was the cause of the problem.

Minor Irritations

Apart from the problems described above, there are a few features of the TE-10A that are annoying down a cave. They are:

- The lack of good attachment points on the drill: We attached the drill by means of a 5 mm cord tied to the main body of the drill above and below the battery pack. However, this cord sometimes interfered with the trigger.
- The stiff bit-locking mechanism: In wet, muddy conditions, it was sometimes difficult to get the mechanism to lock or unlock, and gloves were essential to get sufficient grip on the barrel. Indeed, changing bits could be such a chore that there was sometimes the temptation to select bolts according to the bit in the drill ! Thumb tabs on the chuck barrel would greatly facilitate the changing of bits.
- The battery release mechanism was difficult to use: When gritty, the battery has a tendency to stick in the drill, and then suddenly slide out without warning when being removed. There is no way to grip the battery whilst unlocking it from the drill, and there was always the danger of losing the battery down a pitch.
- The depth gauge was not useful: The irregularity of the rock prevented it from being used as an accurate guide. We resorted to using tape around the drill bits to mark the required depth for HKD bolts; this did, however, prevent those bits from being used for deeper set bolts, entailing unnecessary bit changes.
- We had at least three incidents in which the drill turned on while being moved. This may have been caused by the attachment cord activating the trigger. Uncontrolled activation of the drill

Table 3. Numbers and purposes of each bolt type used during the expedition.

Bolt Type	No. Used	Purpose	Bit Diam	Hole Depth
M10 HKD expansion	45	Hard rock, perm.	12 mm	.....
½ Inch HKD expansion	10	Hard rock, perm.	15 mm	.....
M10 resin	40	Soft rock, perm.	12 mm	8 cm
M10 Rawlbolt	30	Soft rock, temp.	17 mm	4-8 cm
M10 eye-bolt	20	Soft rock, dev.	12 mm	.....

is potentially dangerous, in view of the large number of cords dangling from a typical rigger, and possibly warrants the inclusion of a safety switch.

Bolts Used

We found the most useful bolts to be the stainless steel ½ inch HKD expansion bolts for hard rock, and a combination of the M10 Rawl and stainless steel resin bolts for soft rock. A summary of bolts used during the expedition appears in Table 3.

We avoided the use of galvanised sleeve anchors entirely due to the corrosive nature of the caves. The exception was the ring anchor which we found very useful for deviations. A brief description of the use of each bolt used is given below.

1. Hilti M10 HKD Expansion Bolts

In hard rock, the M10 HKD bolts were found to be exceptionally handy and quick to insert, requiring only a 12 mm bit, a hammer, and a setting tool. The plastic plug retaining the cone inside the anchor was most useful. The only drawback was the need to drill the hole to an accurate depth. We marked the drill bits with tape for this purpose.

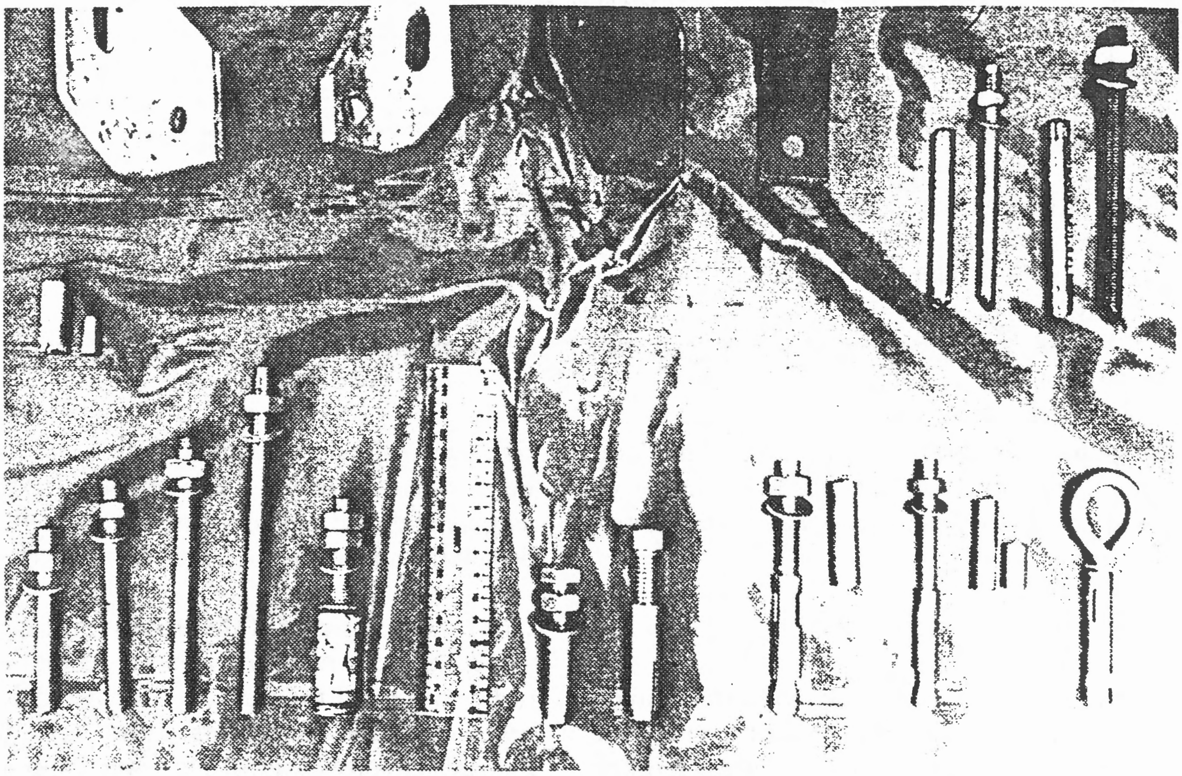
2. M10 Rawlbolt, Double Expansion Bolts

The M10 Rawlbolts were found to be the most useful temporary anchors in soft rock, prior to the setting of resin anchors. The anchor is composed of two opposed expansion cones, which expand the outer sleeve when the thread through the anchor is tightened. The sleeve expands enormously, ensuring excellent grip even in soft rock. Different lengths of thread can be chosen according to how deeply the anchor is to be set into the rock.

One annoying aspect of these bolts is the need for two spanners, and two free hands to set the bolt. In order to tighten the thread within the bolt, it is necessary to tighten two nuts against each other on the thread to provide grip. However, we generally did not have any problems with the anchor turning in the hole as the thread was tightened.

Some judgment is required when tightening the thread and bolting on the hanger. On a few occasions when tightening the thread, the rock around the hole began to crack, requiring the anchor to be re-placed. Increased expansion does not necessarily guarantee a safe placement, as it can compromise the integrity of the rock. Once the anchor is in place, it is then necessary to bolt the hanger to the wall with enough force to ensure that the frictional force between hanger and wall is sufficient to take most of the lateral load. This is necessary in order to avoid an excessive bending torque on the thread where it enters the anchor.

We began to realise after the first two weeks that the nut retaining the hangers on Rawlbolts had a tendency to become loose. We are unsure whether this was due to a slow slippage of the anchor, or due to a loosening of the nut when subjected to periodic loading, such as when prussiking, and to what degree this is related to over-tightening or under-tightening of the retaining nut. We are also uncertain of the loading capacity of loose bolts. We would recommend that all hangers on Rawlbolts be retained by two nuts, which is convenient when



A selection of the diverse bolts and hangers used during the expedition for rigging the SRT pitches in the Chimanimani Caves. (D. Harley)

it comes to de-rigging anyway, and that the tightness of the bolt be checked with a spanner before every descent.

Our policy was to replace all Rawlbolts with stainless steel resin bolts. In general, we found it quite easy to remove the Rawl anchors, which could then be re-used. On only a few occasions the anchor remained stubbornly jammed in the hole.

To summarise, we found the Rawlbolt anchors to be indispensable and effective anchors during exploration in soft-rock caves. However, use of the bolts is accompanied by a definite learning curve and should be used with care.

3. Hilti M10 Resin Bolts

The resin bolts undoubtedly provided the best and most secure anchors in soft rock. Tests conducted under a 'worst case' scenario in soft, coarse-grained, wet sandstone, with the bolt set in an improperly cleaned hole, demonstrated an anchor strength exceeding 5 kN perpendicular to the wall.

The bolts were set by drilling a 12 mm diameter hole, blowing it out with a blow tube, inserting a resin ampoule, and drilling the bolt into the ampoule using the setting tool attachment to the drill. We did not use a glue gun (as opposed to the ampoule system) as the setting time between bolts usually exceeded 10 minutes.

The main objection to the setting of resin bolts was the number of pieces required, and the associated risk of dropping them. Setting a resin bolt requires a 12 mm drill bit, a setting tool drill attachment, the setting tool, and an allen-key. In addition to this there is the resin ampoule, the anchor, a washer and a nut. We found that the most efficient technique was for a rigger to go down on the de-rigging session, drilling the holes and setting the ampoules; and then to go back up again, setting the bolts as the cave was de-rigged behind him. This has the advantage of eliminating all the bit changes

and reducing the number of items that must be handled to set each bolt.

4. Hilti Eye-Bolt Sleeve Anchors

The M10 eye-bolts were found to be very useful for deviations, taking a 12 mm drill bit, being quick to insert, and possessing a ready attachment point for the deviation cord. Two problems were experienced with these bolts, however. The first was the tendency for the expansion nut at the end of the thread to accumulate grit and to stick, preventing the nut from being tightened to expand the sleeve. The second was that the anchor could not be set in hard rock. The tolerance between the drill bit diameter and the eye-bolt was so narrow that it was impossible to insert the bolt, unless the rock was sufficiently soft.

The design of this anchor could surely be improved, and there is a definite need for such an anchor. We also chose not to use these eye-bolts as belay points as the weld at the base of the bolt appeared to be of inadequate and inconsistent quality.

Recommendations to Users of the Hilti TE-10A in Caves

Based on our experiences with the TE-10A in the Chimanimani sandstone caves, we would make the following recommendations to anyone planning to use the TE-10A under similar conditions:

1. Essential Modifications

- Add an attachment point on the battery, able to take a karabiner/maillon, by means of an eye-bolt in the battery case. There is not, without such a modification, any suitable attachment point.

- Seal all batteries entirely. Unfortunately the battery locking mechanism makes this difficult.

2. Non-Essential Modifications

- Add attachment points to the drill, by means of eye-bolts in the casing.
- Place two tabs on the chuck barrel to help with changing of bits.

3. Procedural Recommendations

- Riggers should keep both battery and drill attached at all times. Snapgate karabiners should not be used.

- Mark drill bits with paint for correct depth, and sharpen regularly.

- Batteries should be taken warm off the charger before going down a cave, particularly in cold environments.

Summary and Conclusions

The degree of exploration accomplished could never have been achieved without the use of the Hilti TE-10A. The rigs were infinitely safer than hand-bolted rigs would have been, and the ease and speed of setting bolts greatly facilitated exploration. The ability to drill deep holes was absolutely essential. In most situations, the standard and widely used M8 self-drilling anchors would have been entirely unsuitable. The balance falls heavily in favour of use of a power drill. The modifications required to make the TE-10A suitable for caving use are relatively minor and, once the risks and problems of using the drill down a cave are known, they can easily be avoided. For exploratory work or rigging known caves with permanent bolts, any caving group will find the TE-10A invaluable.

Acknowledgements

We've said it before and we'll say it again: We would like to thank Hilti Fastening Technologies for their considerable and generous support of the Chimanimani Expedition, and for the tremendous and friendly help we received from Hilti staff in Cape Town and Johannesburg. We would also like to thank Rawlbolt for supplying the double-expansion bolts used on the temporary rigs.

Expedition Financial Report

D. Harley

The expedition financial statements were prepared from the books kept by J-P Le Roux, the leader of the expedition. The following points should be noted concerning the financial management of the expedition and the above statements:

1. The main income received by the expedition consisted of fees paid by expedition members, in accordance with their degree of participation. Any surplus accruing from the expedition should be divided on a *pro rata* basis amongst the expedition members.

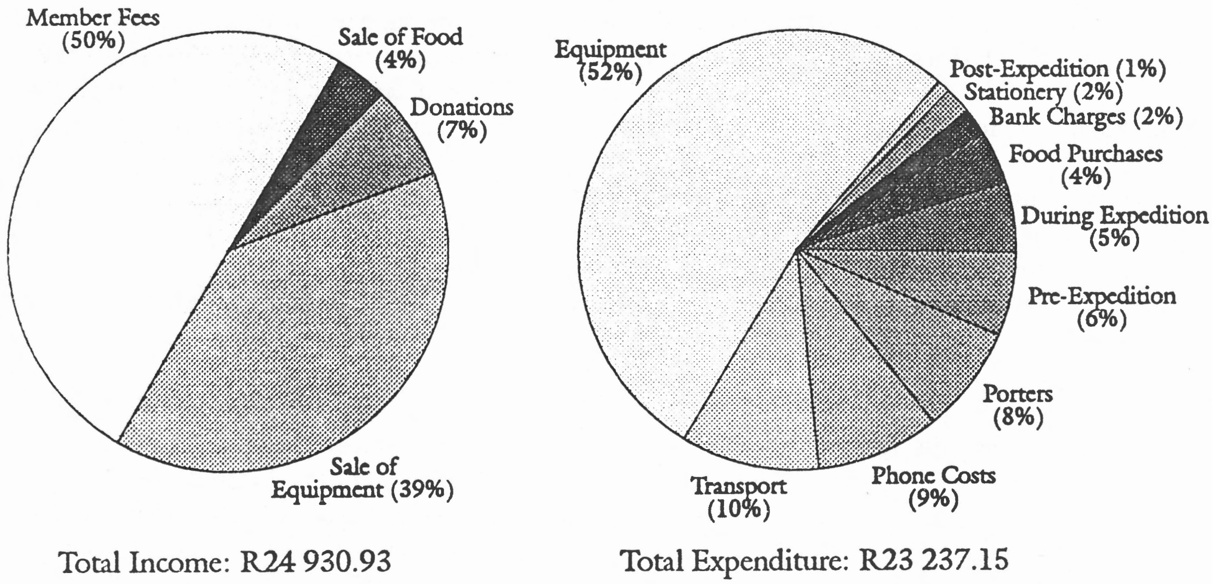
2. Donations consisted mainly of non-returnable deposits from prospective members who withdrew from the expedition.

3. Much of the equipment was purchased on behalf of individual members acquiring personal equipment. Despite considerable sponsorship, purchase of equipment still exceeded sales by R2682.92. However, these statements do not reflect a considerable amount of equipment still in the possession of the expedition, as it is difficult to determine the realistic worth of these assets. They may be carried over to future expeditions.

4. The high telephone, postage, printing, stationary and sundry expenses of R3 987.57 resulted mainly from efforts to obtain sponsorship.

5. Cash Unaccounted For consists almost entirely of cash spent during the expedition. During this period the books were only sporadically updated. Probably the only way to ensure good bookkeeping under expedition conditions is to make one person responsible, and threaten to surcharge him or her for any unaccounted for cash afterwards.

6. Debtors are individual members still owing small amounts on equipment purchased.



Summary of the various categories contributing to the total income and expenditure of the 1993 Chimanimani Expedition.

Table 1. Statement of income and expenditure as at 8 June 1994.

INCOME AND EXPENDITURE

Income

Fees paid	R 12 500.00
Donations	R 1 660.00
Sale of Equipment	R 9 704.62
Sale of Food	R 1 042.00
Interest	R 24.31
	R 24 930.93

Expenditure

Purchase of equipment	R 12 102.54
Purchase of food	R 1 029.58
Phone	R 2 122.40
Postage, Printing & Stationery	R 369.08
Sundry Expenses (Pre-Expedition)	R 1 496.09
Bank Charges	R 458.46
Transport	R 2 382.50
Porters	R 1 922.00
Sundry Expenses (Expedition)	R 537.50
Post Expedition	R 260.00
Cash Unaccounted For	R 557.00
	R 23 237.15

Net Surplus	R 1 693.78

BALANCE SHEET AS AT 8 JUNE 1994

Capital Employed

Current Assets 30/9/92	R 2.46
Net Surplus	R 1 693.78
	R 1 696.24

Employment of Capital

Current Assets	R 799.74
Debtors	R 576.50
	R 1 576.24

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GLOSSARY

Abseil	A method of descending a fixed rope, usually with the aid of a friction device and a sit harness.
ALB	Amazing Levitating Boulder: A boulder that is seemingly suspended in mid-air at the top of a chamber.
Anchor	A secure point of attachment for a ladder or rope at the head of a pitch.
Ascender	A mechanical prussiking device, used for ascending a rope.
Belay (noun)	A natural or artificial secure point of attachment for a ladder or rope at the head of a pitch.
Belay (verb)	The act of making secure the ladder or the lifeliner at the head of a pitch.
Bolt	An expandable metal cylinder which is inserted into a drilled hole to act as an anchor.
Boulder Choke	A collapse of rock from roof to floor which makes further progress difficult or dangerous.
Carbide	Calcium carbide (CaC_2) is a grey substance prepared by heating limestone and coke. It reacts with water to produce acetylene gas.
Cave	An underground natural cavity.
Chamber	Any large cavity inside a cave system.
Chockstone	A rock wedged in a narrow crack.
Choke	A blockage or constriction in a passage, usually of fallen boulders, clay, sand, etc.
Clinometer	A surveying instrument used for measuring the angle of rise or fall in a passage relative to the horizontal.
Cowstails	Two lengths of 9 - 11 mm dynamic rope with karabiners attached to one end. Cowstails are attached to the caver's harness and are used as safety lines while using SRT.
'Croll'	Chest-mounted ascending device made by Petzl.

De-Rig	Removal of all ropes and related rigging equipment from a cave.
Descender	A friction device to facilitate abseiling.
Doline	A surface depression caused by collapse of a cavity below the ground, subsequently deepened by surface erosion caused by run-off.
Fault	A fracture in the earth's crust displacing one side relative to the other.
Fissure	A tight vertical shaft or passage.
Free-Hang	A pitch which takes a line from top to bottom without touching the walls.
Generator	A metal or plastic container attached to a caver's belt which mixes water and carbide to produce acetylene gas that is used to provide light using a burner on a caver's helmet.
Hand-Jammer	An ascender attached to the harness by a cowstail and which has a footloop attached. It is used in tandem with a Petzl 'Croll' when ascending using the 'frog' or 'sit-stand' prussick system.
Harness	A strong webbing seat, or chest, or complete body support for SRT or difficult vertical work.
HKD	Stainless steel cone-anchor bolts manufactured by Hilti. They are used as anchors in hard rock in the caves.
Jamming	A technique involving wedging the body, or part of the body between rock walls in a secure way.
Karabiner	A steel or alloy snap-link used in rope work. Also called a 'krab' or 'biner'.
Pitch	A vertical, or near vertical part of a cave system which requires ladder and lifeline, SRT, or other equipment for its descent and ascent.
Pothole	A vertical entrance shaft or underground pitch.
Prussik	Method of ascending a fixed rope with the aid of mechanical prussicking devices and sit harness.
Rack	An abseiling device using five moveable bars to provide friction.
Re-Belay	A deviation rigged to pull a rope away from rubbing on the wall.
Resurgence	The emergence of an underground stream at the surface.

Rift	A larger version of a fissure.
Sink	A point where a stream drops underground, or has done so in the past.
Squeeze	A very tight section of cave passage.
SRT	Single Rope Technique: A method frequently used by cavers to negotiate drops in caves using a single rope for both descent and ascent.
'Stop'	Abseiling device made by Petzl.
Sump	A place where the passage dips and is filled with water to the roof.
Traverse	A section of cave passage which has to be passed high above the floor or water-level, using natural bridges or ropes.
Y-Hang	A method of rigging a rope using two anchor points, usually to provide a free-hang.

Appendix A:
The Caves of the Chimanimani Mountains

A. Koliasnikoff

EXPLORED CAVES IN THE FRONTIER SHAFTS AREA

Z1	Bounding Pot	-194 m
Z2	Black Crystal Abyss	-186 m
Z3	Big End Chasm	-150 m
Z4	Jungle Pot	-221 m
Z4	Ndoro's Beetle Cave	-51 m
Z7	Zee-in-Ze-Middle	-58 m
Z9	Mwenge Mwena	-305 m
M1	Mozpot	-90 m

UNEXPLORED OR PARTIALLY EXPLORED DOLINES AND OTHER NOTABLE SURFACE FEATURES IN THE FRONTIER SHAFTS AREA

Z5	Doline and associated rift system
Z6	Junction of rifts
Z8	Junction at SW end of rift

UNEXPLORED OR PARTIALLY EXPLORED DOLINES AND OTHER NOTABLE SURFACE FEATURES IN MOZAMBIQUE

M2	Doline
M3	Large doline swallowing surface stream
M4	Labyrinth 2

PARTIALLY EXPLORED CAVES AND DOLINES IN THE RESURGENCE AREA

C9	Resurgence Cave, surveyed
C10	Doline adjacent to resurgence
C11	Troll's Lair Cave, unsurveyed

OTHER CAVES IN THE CHIMANIMANI NATIONAL PARK

C1	Roaring River Caves	C2	Skylight Chamber
C3	Tar Cave	C4	Red Wall Cave
C5	Swart's Gat	C6	Black Rock Caves
C7	The Labyrinth	C8	Terry's Cave

For descriptions of other known caves in the National Park see Le Roux *et al* (1993).

Appendix B:
Deepest and Longest Cave Records

T.F. Truluck

DEEPEST QUARTZITE CAVES IN THE WORLD (OVER 200M)

1.	Sima Auyantepuy Noroeste (Bolivar, Venezuela)	-370 m
2.	Sima Aonda (Bolivar, Venezuela)	-360 m
3.	Sima Aonda 2 (Bolivar, Venezuela)	-325 m
4.	Sima Auyantepuy Norte (Bolivar, Venezuela)	-320 m
5.	Sima Aonda 3 (Bolivar, Venezuela)	-315 m
6.	Sima Major de Sarisarinama (Bolivar, Venezuela)	-314 m
7.	**Mawenge Mwena (Chimanimani, Zimbabwe)**	**-305 m**
8.	Sima Aonda Este 2 (Bolivar, Venezuela)	-295 m
9.	Sima Aonda Sur 2 (Bolivar, Venezuela)	-290 m
10.	Sima Yuruani Tepuy (Bolivar, Venezuela)	-252 m
11.	Sima Manor de Sarisarinama (Bolivar, Venezuela)	-248 m
12.	Sima Auyantepuy Norte 2 (Bolivar, Venezuela)	-230 m
13.	**Jungle Pot (Chimanimani, Zimbabwe)**	**-221 m**
14.	Cova del Serrat del Vent (Barcelona, Spain)	-215 m
15.	Sima Aonda E4 (Bolivar, Venezuela)	-210 m
16.	Sima de la Lluvia (Bolivar, Venezuela)	-202 m

DEEPEST CAVES IN AFRICA (OVER 200M)

1.	Anou Ifflis (Ras Timoudoiune, Algeria)	-1170 m
2.	Anou Boussouil (Terga m'ta Roumi, Algeria)	-805 m
3.	Kef Toghobeit (Rif, Morrocco)	-722 m
4.	Cueva del Viento (Canary Islands)	-478 m
5.	Leviathan Cave (Chyulu Mountains, Kenya)	-465 m
6.	Anou Achra Lemoun (Ras Timoudoiune, Algeria)	-326 m
7.	Kef Tikhoubai (Tazekka, Morrocco)	-310 m
8.	**Mawenge Mwena (Chimanimani, Zimbabwe)**	**-305 m**
9.	Bushmansgat (Northern Cape, RSA)	-295 m
10.	Anou Bou Hadjar (Ras Timoudoiune, Algeria)	-273 m
11.	Friouato (Messaoud, Morrocco)	-271 m
12.	Rhar Djebel Serdj (Ousseltia, Tunisia)	-267 m
13.	Anou Inker Temdat (Azerou Thaltatt, Algeria)	-255 m
14.	Ain Melghfi (Middle Atlas, Morrocco)	-251 m
15.	**Jungle Pot (Chimanimani, Zimbabwe)**	**-221 m**
16.	Kef El Sao (Bou-Messaoud, Morrocco)	-220 m
17.	Rhar Dar el Beida (Djebel Taya, Algeria)	-215 m
18.	Kef Anefid (Middle Atlas, Morrocco)	-214 m
19.	Harasib Cave (Otavi, Namibia)	-210 m
20.	Ubuwumo bwa Musanze (Runengeri, Rwanda)	-210 m
21.	Anou Timoudouine (Ras Timoudoiune, Algeria)	-205 m

DEEPEST CAVES IN SOUTHERN AFRICA (OVER 100M)

1.	**Mawenge Mwena (Chimanimani, Zimbabwe)**	**-305 m**
2.	Bushmansgat (Northern Cape, RSA)	-295 m
3.	**Jungle Pot (Chimanimani, Zimbabwe)**	**-221 m**
4.	Harasib Cave (Otavi, Namibia)	-210 m
5.	**Bounding Pot (Chimanimani, Zimbabwe)**	**-194 m**
6.	Chinhoyi Cave (Chinoyi, Zimbabwe)	-190 m
7.	**Black Crystal Abyss (Chimanimani, Zimbabwe)**	**-187 m**
8.	Westdriefontein (PWV, RSA)	-183 m
9.	Guinas Lake (Otavi, Namibia)	-157 m
10.	Wolkberg (Northern Transvaal, RSA)	-152 m
11.	**Big End Chasm (Chimanimani, Zimbabwe)**	**-150 m**
12.	Dragon's Breath Hole (Otavi, Namibia)	-150 m
13.	Aigamas Cave (Otavi, Namibia)	-131 m
14.	Chaos Cave (PWV, RSA)	-112 m
15.	Makwen's Bathole (Northern Transvaal, RSA)	-110 m
16.	Arnhem Cave (Windhoek, Namibia)	-110 m
17.	Wondergat (PWV, RSA)	-104 m

DEEPEST CAVES IN ZIMBABWE (DEEPER THAN 50 M)

1.	**Mawenge Mwena (Chimanimani)**	**-305 m**
2.	**Jungle Pot (Chimanimani)**	**-221 m**
3.	**Bounding Pot (Chimanimani)**	**-194 m**
5.	Chinhoyi Cave (Chinhoyi)	-190 m
4.	**Black Crystal Abyss (Chimanimani)**	**-187 m**
6.	**Big End Chasm (Chimanimani)**	**-150 m**
7.	Highlands Cave (Chinhoyi)	-75 m
8.	**Zee-in-Ze-Middle (Chimanimani)**	**-58 m**
9.	**Ndoro's Beetle Cave (Chimanimani)**	**-51 m**
10.	Ulster Cave (Chinhoyi)	-50 m
11.	Bashungwe Cave (Hurongwe)	- 50 m

LONGEST CAVES IN ZIMBABWE (LONGER THAN 200 M)

1.	Badze Cave (Hurongwe)	1 037 m
2.	Chinhoyi Cave (Chinhoyi)	887 m
3.	Magweto Caverns (Hurongwe)	698 m
4.	Highlands Cave (Chinhoyi)	691 m
5.	**Mawenge Mwena (Chimanimani)**	**622 m**
6.	Chimsoro Cave (Mafungabusi)	532 m
7.	**Bounding Pot (Chimanimani)**	**462 m**
8.	Bashungwe Cave (Hurongwe)	457 m
9.	**Black Crystal Abyss (Chimanimani)**	**407 m**
10.	**Big End Chasm (Chimanimani)**	**390 m**
11.	**Jungle Pot (Chimanimani)**	**380 m**
12.	Mabura #1 Cave (Mafungabusi)	332 m
13.	Ulster Cave (Chinhoyi)	242 m
14.	Zvarayi Cave (Chinhoyi)	241 m
15.	Kau-Kua Cave (Chinhoyi)	232 m
16.	**Resurgence Cave (Chimanimani)**	**217 m**
17.	**Zee-in-Ze-Middle (Chimanimani)**	**215 m**
18.	Cotswold #1 Cave (Chinhoyi)	208 m

Appendix B: Deepest and Longest Cave Records